Digital Financial Inclusion and Energy and Environment: Global positioning of Sub-Saharan African countries

Nancy Mukalay[1] *and Roula Inglesi-Lotz*

Department of Economics, University of Pretoria, South Africa

Highlights

- Most research focuses on the role of financial inclusion in economic growth , but in energy and environment is limited.
- A comparative analysis of digital financial inclusion proxies of 39 countries based on their geographic position.
- Social-economic indicators in East Asia and the Pacific region have almost reached these in Europe and Central Asia.
- Compared to other regions, SSA is the only region stagnated in poverty.
- Higher financial inclusion proxies are associated with higher energy consumption and CO2 emission.

Abstract

The Bretton Woods institutions and the G20 have undertaken the initiative to promote financial inclusion in Sub-Saharan Africa and South Asia to reduce the high rate of economic poverty. Due to advanced technology in financial services, Sub-Saharan Africa and South Africa have included a lot of people in the financial system. Thereby digital financial inclusion influences energy consumption and the environment by their pass-through effect on economic growth. This paper evaluates the expansion of innovative digital services and financial inclusion on energy consumption and the environment in different countries according to their geographical position. Regarding socio-economic indicators and the proportion of people who claim to be owners of an account at a bank or financial institution, SSA is still stagnating in poverty and has the lowest percentage compared to other regions. Using the Global Findex data, we find that higher financial inclusion proxies are related to higher energy consumption and CO2 emission. At the same time, the relationship is not always linear between technology, energy consumption and CO2 emission.

***Keywords*:** Digital Financial Inclusion; Sustainable Developing Goals (SDG); Energy usage; Sub-Saharan Africa.

[1] Corresponding author: u16307314@tuks.co.za

Abbreviations: DFI, digital financial inclusion; DFS, digital financial services; FDI, foreign direct investment; OECD, organisation for economic co-operation and development; SSA, South Saharan Africa; SA, south Asia; MENA, middle east and north Africa; LAC, Latin America and Caribbean; EAP, east Asia and pacific; ECA, European and central Asia; BTU, british thermal unit; Gt, gigations; Th.kt, thousand kilotons; Mt, metric tons; Quad.,quadrillions; CONT, country with no transition; TRAMID, transitioning towards middle income.

1. Introduction

Global energy consumption has been steadily rising in recent decades. Based on the International Energy Agency (IEA) outlook report, primary energy consumption and CO2 emissions grew respectively by 2.3%, almost double the average rate growth since 2010 and 1.7% to reach a historic high of 33.1 gigatons (Gt) CO2 in 2018 [1]. A more significant part of the increase in energy consumption results from fossil energy, particularly oil, coal and gas. Especially with the rapid development of industrialisation and modernisation, many countries still rely on non-renewable energy to support their economic growth [2]. Empirical studies find that different countries' levels of economic growth might be explained by the difference in energy consumed. For instance, the increase in energy consumption of non-OECD countries can be explained by the firm and sustainable economic growth and improvement in livelihoods in emerging countries, especially in China and India [3]. Energy consumption is expected to increase by nearly 50% between 2018 and 2050 in non-OECD countries while only 15% in OECD countries [1]. The assumption on the Environmental Kuznets curve states that initially country's economic growth cause deterioration of the environment, but after reaching a certain level of development, it starts improving environment quality [4]. According to the World Bank, developing countries (China and India) are responsible for 62% (34%) of the global total carbon dioxide (CO2) emissions [5]. On the other hand, there is a need in developing and emerging countries to build the financial sector to stimulate real economic growth and reduce poverty levels. The main challenge these countries face in the current green development tendency is to what extent an increase in fossil energy is considered a principal agent of CO2 emissions that negatively affects the environment.

By contrast to the Millennium Development Goals (MDG), which were more directed to developing countries, the Sustainable Developing Goals (SDG) are a worldwide program to end poverty and ensure economic, environmental and social sustainability [6]. These SDG are as relevant for developing countries as for developed countries. Meanwhile, almost 2.5 billion people (or about half the working-age population), especially in SSA and Pacific Asia, do not have access to financial services [7].To conduce to sustainable economic growth, increase income, reduce poverty, promote entrepreneurship and job creation, a financial system needs to include many people in the system [8]. Furthermore, compared to others regions in the world, Sub-Saharan Africa and South Asia register also a high rate of poverty,

illiteracy, child and maternal mortality. This led to the initiative to promote financial inclusion, especially in developing and emerging economies by the G20 and the World Bank, to reduce poverty. By expanding innovative digital services, the financial system has included 700 million adults worldwide to gain formal financial assistance between 2011 and 2014 [9]. This is proved by the fact that households' chance to own a mobile phone in developing and emerging countries is much higher than having access to electricity or improved sanitation. Indeed, more recently, Asia-pacific countries and Sub-Saharan African countries like Ghana, Kenya, Uganda, Rwanda, Tanzania, South Africa, Nigeria and Zambia have adopted advanced technology in financial services. According to Global Findex data by Demirgüç-Kunt et al. [10], account ownership with a mobile-money provider or with a financial institution in SSA countries rate reached 43% in 2017 while in 2011 it was only 23%.

An inclusive financial system provides easy access to credit, payment, saving and assurance to individuals and firms especially the disadvantaged ones. By providing easy access to financial services, a financial system allows disadvantaged households to borrow, save, build their assets, entrepreneur in agriculture activities, and build resilience against any economic shocks, thus upgrading their livelihoods. In addition, due to financial inclusion, newly firms may take advantage of promising growth opportunities instead of relying on their constrained earnings to extend their investments [11]. On top of that, financial inclusion might improve access to financial services and the quality and cost of the services that small and new firms might gain from the financial sector. These elements are important catalysers conducive to the profitability and prosperity of firms and the economy [12]. The policy to provide access to financial services to a large portion of the population has increased innovative technological solutions [12]. These innovative technologies can reduce costs and improve the economy's overall efficiency. Therefore, many countries have made financial inclusion a policy priority. The financial inclusion initiative has come from policymakers, the financial regulators and the financial sector [13].

The basic idea is that the expansion of DFI relies not just on the strength of the financial sector but also on the entire ecosystem, including economic, energy, technological, environmental, and social sectors. For instance, to include a large number of people and to reduce the technological gap in the financial industry between Sub-Saharan African countries and developed countries, Kabakova et al. [14] note that financial inclusion in developing countries recently has begun to rely on the use of technology with the support of mobile phone. Consequently, to understand the differences or similarities in the rate of financial inclusion and poverty level between Sub-Saharan African countries and other regions globally, a comparative analysis is a fundamental approach to formulate the hypothesis of the relationship between these sectors. Through these channels, the assumption is based on the fact that digital DFI influences energy consumption and the environment by their pass-through effect on economic growth. Greater access to finance influences individuals' and firms' economic behaviours. In other words, financial

inclusion is accompanied by improving economic activities and economic development, which may affect energy consumption decisions and the environment. Technological advancement has incorporated an enormous share of the population in the financial market. In the context of the development of the digital economy, information and communication technology are among the factors that influence energy consumption [1]. Given this, energy and environmental economics research is extended to other factors like technological advancement. Pacific Asia and Sub-Saharan African countries are leading an exciting process of financial inclusion through mobile phone payment, cards linked to a reliable digital payment system solution, and computers connected to the internet. Inclusive and affordable financial services would create opportunities for growth and employment, especially for rural households. Therefore, it is crucial to analyse channels in which digital financial services influence energy consumption and the environment. Developing and emerging economies are overgrowing, which has created an increase in energy consumption. This situation will require us to deal with global emissions of greenhouse gases in the future [15]. For these few reasons listed above, the need to investigate the status quo of the digital technology services and financial inclusion evolve vis-à-vis energy and environment development becomes very important.

This study aims to evaluate the expansion of innovative digital services and financial inclusion on energy consumption and environment in different countries groups according to the geographical position. Secondly, as Sub-Saharan African countries have adopted advanced technology in financial services, this study will position the African continent compared to other parts of the world. On the other hand, the study will evaluate different types of energy, including oil production, natural gas, hydroelectric power, solar energy and wind energy and compare them to other country groups' energy sources. Therefore, the conclusions of this study are tools for policymakers and financial stakeholders to design policies in allocating energy resources, reducing environmental deterioration while promoting sustainable economic and social development in emerging and developing countries.

Apart from the introduction, the paper is structured as follows: Section 2 presents a resume of the relevant literature. In contrast, section 3 provides a theoretical framework for the analysis and data used in this study. Finally, section 4 discusses the comparative analysis.

2. Literature review

The literature concerning the role of digital financial inclusion in energy and the environment is exceptionally scarce. Thereby, the relationship between DFI, energy, and the environment is not well-established. Most papers are interested in examining the role of financial inclusion in poverty reduction,

economic growth, or development. Others are focused more on the relationship between financial development, energy consumption and economic growth. For this paper, we have noticed that DFI may be among the factors affecting energy consumption and the environment by their pass-through effect on economic growth and poverty reduction. Economists like Goldsmith [16] and Shaw [17] consider the financial market one of the economic activity determinants. From their point of view, the reason why countries grow at different rates might be explained by differences in the quality and quantity of services provided by financial institutions [18] . Other economists like Robinson [19] see the financial sector as a handmaiden to the industrial sector, reacting efficiently to other factors that produced differences in growth rates between cross-countries. We base our idea of the connection between finance, entrepreneurship, and economic growth on the insights of Knight [20], Schumpeter [21] and King [18]. Therefore, this section provides an overview of papers related to the channel of digital financial inclusion in economic growth, energy and the environment.

A study by Kim et al. [22] investigates the empirical evidence on the relationship between financial inclusion and economic growth in the Organization of Islamic Cooperation (OIC) countries using the panel VAR analysis. The result shows a positive relationship between financial inclusion and economic growth in line with the hypothesis. While a lot of papers find long and short-run causalities from energy consumption to GDP [23], [24], [25] and others find bidirectional causality between energy consumption and economic growth [26]. Based on these findings, financial inclusion might influence energy consumption positively through economic growth and vice versa. An increasing number of papers show that financial inclusion can positively affect an individual's welfare. These papers have used a series of models how exclusiveness in the financial system causes poverty and inequality levels to increase [27]; [28]; [29]; [30]. In contrast to these findings, the paper by Neaime et al. [31] investigates the influences of financial inclusion on income inequality, poverty, and financial stability in 8 MENA countries using the Generalised Method Moment model and Generalised Least Squares. The paper finds that financial inclusion does not influence poverty. In general, the literature has found that providing easy access to financial services increases savings [32]; [33], productive investment [34], consumption [34], [33], and female empowerment [35]. On the other hand, for companies, one of the critical roles of the financial system is to organise the allocation of funds from surplus to deficits agents. We may find productive companies with great opportunities to grow businesses that need extra resources to finance fixed and working assets among these deficit agents. Without financial inclusion, some companies may not take advantage of business opportunities due to principal-agent problems or transaction costs [7] .

Beck et al. [36] analyse a new set of financial sector outreach for cross countries. Using the ordinary least square (OLS) and ordered probit, they find that a technologically advanced and inclusive financial system

might potentially reduce asymmetric information and transaction cost, consequently influencing investment decisions. It also increases saving rates, encourages technological innovation and progressively causes long-run growth, which we think may affect energy and the environment. Talking about the effect on the environment, Le et al. [37] investigate the empirical evidence on the impact of financial inclusion on CO2 emission for 31 Asian countries. Apart from industrialisation, urbanisation and FDI, among factors that lead to higher emissions of CO2 in the region, the study finds also financial inclusion. In poor and emerging countries, the initiative to promote financial inclusion is more and more associated with the use of technology [14]. Mobile banking and mobile money are two of the most evident technologies to support financial inclusion.

More recently, developing and emerging countries have started to give much attention to the role of mobile money and mobile banking in increasing financial inclusion. In Africa, many countries have initiated an impressive process of financial inclusion through mobile phone payment solutions. For the simple reason that mobile phone penetration has recently increased remarkably worldwide. Many individuals are now well within reach, even in many poor and emerging countries [7]. For instance, the study of Andrianaivo et al. [38] analyses if mobile phone penetration in Africa affects economic growth through financial inclusion using the first lagged value and the two-step System GMM. The authors find that mobile phone penetration affects economic growth in the continent.

Furthermore, several deposits and loans per person are used as proxies for financial inclusion. The study finds a positive and significant effect on the relationship between mobile phone penetration and financial inclusion. Beck et al. [39] investigate the impact of payment technology innovation (mobile money) on entrepreneurship and economic development in a quantitative dynamic general equilibrium model. They find that mobile payments help develop new business opportunities and reduce the degree of information asymmetry; therefore, it improves entrepreneurial performance.

Based on the Schumpeterian analysis, excellent access to credit by entrepreneurs is conducive to growth and prosperity. Bittencourt [40] investigates the role of access to finance in generating economic growth in four different countries such as Argentina, Bolivia, Brazil and Peru. Using a panel time-series data analysis, the results show that access to finance encourages firms or entrepreneurs to invest in productive activities and generate growth in these countries. These results support Schumpeterian ideas on finance, which point out how vital finance's role is in developing growth and development. In addition to generating growth and improving the poorest well-being, these factors can increase pressure on energy consumption and environmental deterioration in these countries. These factors may encourage economic agents to revise their energy demand decision. On the other side, empirical estimates suggest that energy consumption increases with the allocation of credit to the most productive entrepreneurs and firms. After

a threshold level of credit allocation to firms, the financial system monitors the credit allocation and incite firms to develop energy-efficient technology for their business activities, resulting in a downfall of energy intensity and improved environment quality [15].

In addition, technology has also impacted other areas in the financial sector. For example, modern information technologies have allowed banks to be implanted in the previous unbanked area via bank correspondents. New technology has reduced the time and cost of borrower identification and credit reporting for financial intermediates, allowing banks to provide services to individuals who would probably be excluded from financial assistance if these new technologies do not exist [7]. The report of the International Monetary Fund [41] suggests that digitalised financial services can affect international financial system' organisations. Recent technology advances and cost reductions in financial services, for instance, cloud computing and the proliferation of mobile phones, have effectively increased the access by individuals and firms to payment instruments previously reserved only to banks and other financial institutions.

In the same thread of ideas, a comparable study of Zaghdoudi [42] examines the empirical relationship between internet usage, renewable energy, electricity consumption and economic growth in 31 advanced economies using the Panel autoregressive distributed lag method and Dynamic Ordinary Least Squares method. The results show that renewable energy has a negative and significant effect on electricity consumption. However, the result shows a substantial and positive impact on electricity consumption in the short-run regarding economic growth. The study, therefore, confirms that advanced economies still rely on non-renewable energy used to support their economic growth and the increase in electricity demand from internet usage. To increase renewable electricity production and reduce pollution, action needs to be taken, such as increasing investment in renewable energy and green I.T. in these countries. Lange et al.'s (2020) [43] study examine if digitalisation has reduced energy consumption using an analytical model. Combining both empirical and theoretical results, the study suggests two increasing and two reducing digitalisation effects on energy consumption. Digitalisation has a direct and increasing-energy impact on economic growth. In other words, digitalisation increases energy consumption to support strong growth.

On the other hand, digitalisation brings energy-reducing effects through energy efficiency and sectoral change. By using ICT, a country increases energy efficiency in its economy. While the impact of digitalisation on the tertiarisation of the economy is not clear, some evidence suggests it has an energy-reducing effect but is non-significant.

We cannot discuss the role of innovative technology in the financial sector without discussing the role of Information and Communication Technology (ICT) on the entire economy. Thereby, the production and consumption of ICT goods and services are rapidly growing worldwide. This trend goes along with a corresponding increase in electricity and environmental effects caused by ICT [44]. ICT has been recognised as playing a pivotal role to improve productivity and energy efficiency. However, there is no consensus on its effect on the environment. Several empirical studies find a positive part of ICT in mitigating greenhouse gas emissions.

In contrast, others suggest that the development of ICT goods and services contribute to GHG emissions through the increased use of electricity which is one of the primary sources of global CO2 emissions [45]. Sadorsky [46] investigates the impact of ICT on electricity consumption in emerging economies using panel data analysis methods (dynamic generalised methods of moments [GMM], pooled ordinary least squares, fixed effects and random effects). The results are mixed depending on the methodology applied. For instance, the impact of ICT on electricity consumption is negative and non-significant under the dynamic-GMM and pooled OLS.

While under fixed and random effects, the ICT has a significant positive impact on electricity consumption. Salahuddin et al. [47] examine how ICT and economic growth affect electricity consumption in OECD countries. The study uses a panel unit root test to evaluate the presence of cross-section dependence. The Petroni cointegration test is performed to see if variables are cointegrated between them. Finally, the Pooled Mean Group is used to estimate the short and the long run. The results show that ICT use and economic growth have a significant and high positive relationship with electricity consumption in the short and the long run. In addition, causality results show that electricity consumption conduces to economic growth while both ICT proxies such as mobile and internet use contribute to electricity consumption and economic development.

3. Methodology and data

The comparative analysis will allow us to formulate the hypotheses carefully as the first step of research; the second step is a similar theory demonstration. At the same time, the third step is the examination of studies cases to highlight similarities and differences among them [48]. In the case of this comparison analysis, economic, financial, energetical, environmental and social indicators are compared to different groups countries according to their geographical position. It is appropriate to compare sustainable development indicators for other countries according to their geographical position for the simple reason that SGD goals are as relevant for the USA as for Liberia [6]. Inglesi-Lotz et al. [49] motivate the

comparison of the electricity intensities between South Africa and OECD countries because South Africa should conform to the "best practice" of OECD countries to learn and improve. A total of 1.3 billion people lack access to electricity; almost half of these people live in Sub-Saharan Africa [50]. This energy gap has contributed to slow economic development. However, during the 2000s, China and India grew three to four times faster than the OECD average and the number of developing countries more than halved [3]. Thereby, the comparative analysis evaluates the different type of energy consumption, including oil production, natural gas, hydroelectric energy, solar energy and wind energy vis-a-vis to economic growth and compare them to other groups countries such as SSA, South Asia, Europe & Central Asia, Middle East & North Africa, East Asia& Pacific and Latin America & Caribbean.

Far from being developed like the financial system in OECD countries, Olaniyi et al. [51] note that the financial system in SSA countries has grown highly in size and complexity in the last decades. Sub-Saharan African countries opt for a digital financial inclusion strategy to fill the gap. Given this, financial inclusion and digital technology proxies vis-à-vis to energy consumption and environment development are compared the status quo in different countries according to their geographical position, focusing on Sub-Saharan Africa region Africa. To see where they are doing well and where they need to improve. For that reason, the evolution of the energy consumption per capita is compared to the development of financial inclusion proxies such as automated teller machines (ATM) per 100 000 adults, bank branches (BRCH) per 100 000 adults, deposit accounts with commercial banks (DEPO) per 1000 adults and borrowers from the commercial bank (BOR) per 1000 adults as the mobile phone has helped people to have access to financial services in Africa. It is added as financial inclusion proxy.

Additionally, in Africa, financial services rely on technology, as we mentioned previously. Mobile cellular subscriptions (MOB) per 100 people and individuals using the internet (INT) (% of the population) used as ICT proxies. All of this is compared to the evolution of energy consumption (E.C.) (kg of oil equivalent per capita) and CO2 emissions (metric tons per capita) of different group countries according to their geographical position.

The comparative analysis employs annual time series covering the period from 1990 to 2019. The data to be used for the close analysis and the sample of countries used for correlation are presented in the following tables:

Table 1: Variables used and data sources

Variable	Acronym used in this study	Unit of measurement	Author	Source
Gross Domestic Product	GDP	• Per capita	[51]	WDI (2020)
Energy Consumption	E.C.	• Kg of oil equivalent per capita	[52] ; [53]	IEA (2020)
Greenhouse Gas Emissions	GHG	• CO2 metric tons per capita	[37]	WDI (2020)
Financial Inclusion	FI	• ATM per 100,000 adults • BRCH per 100,000 adults • DEPO per 1000 adults • BOR per 1000 adults	[54] ; [55],	Global Findex (2020)
Information and Communication Technology	ICT	• MOB per 100 people • INT per 100 people	[47]; [56]	WDI (2020)

Table 2: Countries selected.

East Asia & Pacific	Brunei Singapore Thailand	Country with no transition Country with no transition Transitioning towards Middle Inc
Europe & Central Asia	Croatia Estonia Italy Latvia Uruguay Tajikistan Turkey	Country with no transition Country with no transitionCountry with no transition Country with no transition Country with no transition Country with no transition Country with no transition
Latin American & Caribbean	Argentina Brazil Colombia Costa Rica Dominican, Rep Haiti Peru	Country with no transition Transitioning towards Middle Inc Transitioning towards Middle Inc. Transitioning towards Middle Inc. Country with no transition Transitioning towards Middle Inc. Transitioning towards Middle Inc.
Middle East and North America	Egypt Israel Qatar Tunisia	Country with no transition Country with no transition Country with no transition Country with no transition
South Asia	Bangladesh Pakistan	Transitioning towards Middle Inc. Transitioning towards Middle Inc.

Sub-Saharan Africa	Botswana	Country with no transition
	Congo, Dem, Rep.	Country with no transition
	Cameroon	Transitioning towards Middle Inc
	Guinea	Country with no transition
	Eswatini	Country with no transition
	Ethiopia	Country with no transition
	Namibia	Transitioning towards Middle Inc.
	Ghana	Transitioning towards Middle Inc.
	Kenya	Transitioning towards Middle Inc.
	Tanzania	Transitioning towards Middle Inc.
	Uganda	Country with no transition
	Lesotho	Transitioning towards Middle Inc.
	Madagascar	Country with no transition
	Mozambique	Country with no transition
	Seychelles	Country with no transition
	Zambia	Transitioning towards Middle Inc
	Zimbabwe	Transitioning towards Middle Inc.

4. Empirical Analysis

4.1. Development of digital financial inclusion and Poverty

Despite the recent economic performance, most of the population in Africa and South Asia is still stagnated in poverty across these regions. Socio-economic indicators such as employment, literacy, inequality, education, income, access to electricity and adequate sanitation have not improved as expected. In addition, poor basic infrastructure and low access to financial services constitute a massive barrier to entrepreneurship opportunities for young graduates and rural households. Indeed, financial exclusion contributes mainly to the impoverishment of the population in Africa and South Asia. Financial inclusion refers to the access to financial products and services such as payments, transactions, savings, credit and insurance by a large segment of individuals and firms, especially for the disadvantaged ones. Owning a transaction account with a financial institution or a mobile money provider is considered the first step to financial inclusion. The simple reason is that the transaction accounts help individuals store, receive and send money. This will result in higher savings, more disposable income, especially for rural households, and a broader deposit base for financial institutions. Significant savings, a high volume of transactions, easy access to loans and insurance increase economic activities and promote self-reliance for low-income households and small businesses. Some empirical researches mentioned that in Sub-Saharan Africa, only 25 % had an account, and only 5 % had accessed a loan from a financial institution in 2011. The lack and poor economic infrastructure constitutes an additional barrier for financial service providers. Higher financial infrastructure quality promotes low transaction costs, accurate risk evaluation, consumer protection, improving credit facilities and access to capital.

The fast technological diffusion in developing countries and especially the proliferation of mobile phones has reformed the way financial services are provided and innovated additional ways of serving the poor. In SSA countries like Kenya, Ghana, and Rwanda, more than 40 % of agricultural platforms accept mobile-money payments [57]. Consequently, mobile money is considered the main contributor to the growth of rural and agricultural platforms. Some empirical research mentioned that modern digital banking started with cards linked to a reliable digital payment system and automated teller machines (ATM) in the banking sector. Still, mobile and internet banking offer effective and rapid delivery channels for traditional and new banking products. DFI refers to accessing financial services through innovative technologies like mobile phones, internet banking, digital payment platforms and electronic money models. The expansion of digital financial inclusion relies mainly on other areas that make up the financial market. One weakness in a particular area may affect the entire financial market growth.

4.2. Evaluation of the socio-economic state of different geographic regions

To understand the variation in the development of digital financial inclusion and the rate of financial inclusion in different regions of the world, critical economic, technologic, energetic and social indicators need to be compared for the simple reason that the extent to which a financial inclusion grows relies mainly on others components that forms an entire economy of a country. Tables 3 and 4 overview different indicators sensitive to influence DFS. A technological advanced and inclusive financial sector facilitate the distribution and the extension of financial services such as payment transactions from big cities to rural areas and vis-versa, deposits, savings, micro-credits and assurance. In addition, to speed distribution and extension, the DFI might have some positive repercussions on inclusive economic growth. Empirical studies like [22] states that higher economic growth leads firms to extend their businesses, which means they will need the energy to support production, consequently may produce higher CO2 emission. Based on transitivity principle, DFI may have some positive spillover effect on energy consumption and CO2 emission. . On the other hand, DFI may directly affect energy and the environment when a broad and high-quality energy network in place favours the delivery of digital financial services [14]. The size of the population may constitute a considerable opportunity for DFS development. For instance, a significant population may create opportunity of expansion for the financial sector in terms of savings, assurance, investment and other needs.

Table 3. Population, Economy size, Energy consumption and CO2 emission.

Grp country	Population[a]		GDP[b]			Energy consumption[c]		CO2 emission[c]	
	Millions	%	$Billion	%	Growth rate	Quad. BTU	%	Th..kt	%
SSA	1107	14	1854	2	2.3	11.6	1.9	880	2.5
MENA	456	6	3500	4	0.5	45.8	7.6	2825	8.1
LAC	646	8	6215	7	1.0	36.96	6.1	1695	4.8
EAP	2340	31	2491	29	3.6	220.9	36.7	14126	40.5
ECA	920	12	24579	29	1.6	129.9	21.6	6428	18.4
SA	1835	24	3548	4	4	37.3	6.1	3020	8.6
World	7509	100	84965	100	-	599	100	34838	100

[a] Fred (2019); [b]WDI (2019); [c]Human Progress (2018) (2019)

Table 4. Some critical social & economic indicators

Grp. Country	GDP per capita[a]	Literacy rate[a]	Life expects. at birth[a]	% of people using Sanitation services[b]	Access to electric. % of population
SSA	1675	65.4	61	30.9	46.74
MENA	7663	79.3	74	90	97.2
LAC	9615	94.4	75	86.7	98.4
EAP	10645	95.7	76	84	98.12
ECA	26693	98	78	96.6	99.9
SA	1932	72.9	76	58.7	98.1
World	10935	86.24	69	73.39	89.4

[a] WDI(2019)

[b]WDI(2017)

A comparison of the social-economic indicators in Sub-Saharan Africa with that of other regions of the world suggests that Sub-Saharan Africa is still the poorest region in the world (Table 3 & 4). With around 1,107 million people that is 14 % of the total population in the world, the GDP per capita remains below 2000 $ U.S. In terms of energy consumption and CO2 emissions, with only 11.6 quadrillions BTU and 880 thousand kt, SSA account for only 1.9 % and 2.5% of global energy consumption and CO2 emissions. Against the backdrop of global energy-related CO2 emissions taking place since, in the 19th century, SSA is considered a good pupil. According to Table 3, South Asia is the fastest economic growth region due mainly to infrastructure development. With countries like China, Japan and Korea, East Asia and the Pacific is the highest energy-consuming region, consequently the greater producer of CO2 emissions. In 2019, 220.9 quadrillions BTU was consumed, and it is responsible for 36.7 % of the production of CO2 emissions in the world (Tab.3). According to table 4, in 2019, the GDP per capita was 1675$ U.S. that is fifteen times compared to Europe and Central Asia. Less than 50 % of the population

still have no access to electricity and decent sanitation service in SSA. This is very low compared to other regions like Latin America & Caribbean, and South Asia.

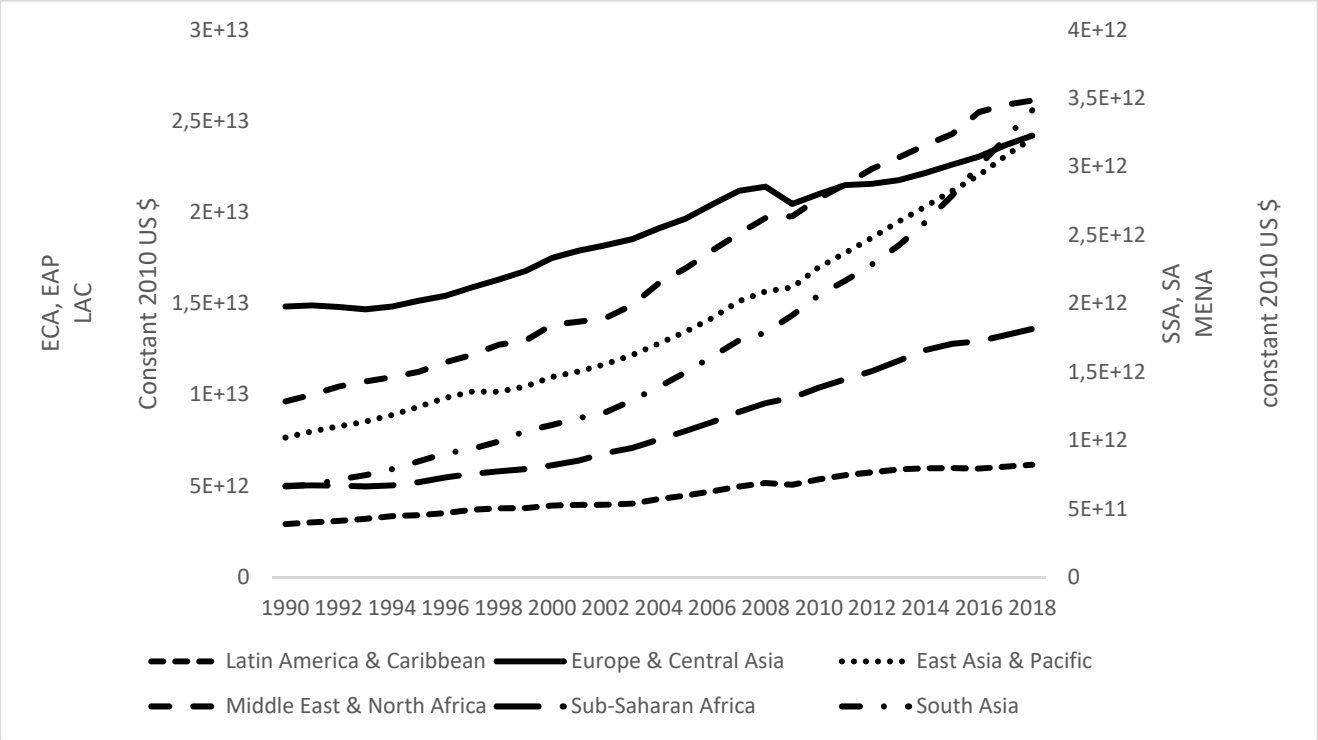
Additionally, SSA still has the lowest life expectancy compared to other regions. According to the table, in 2019, life expectancy at birth was 61 years only, while in ECA, the life expectation is 78 years. The same situation is observed with the literacy rate being very low in SSA compared to the world average of 86.24 %.

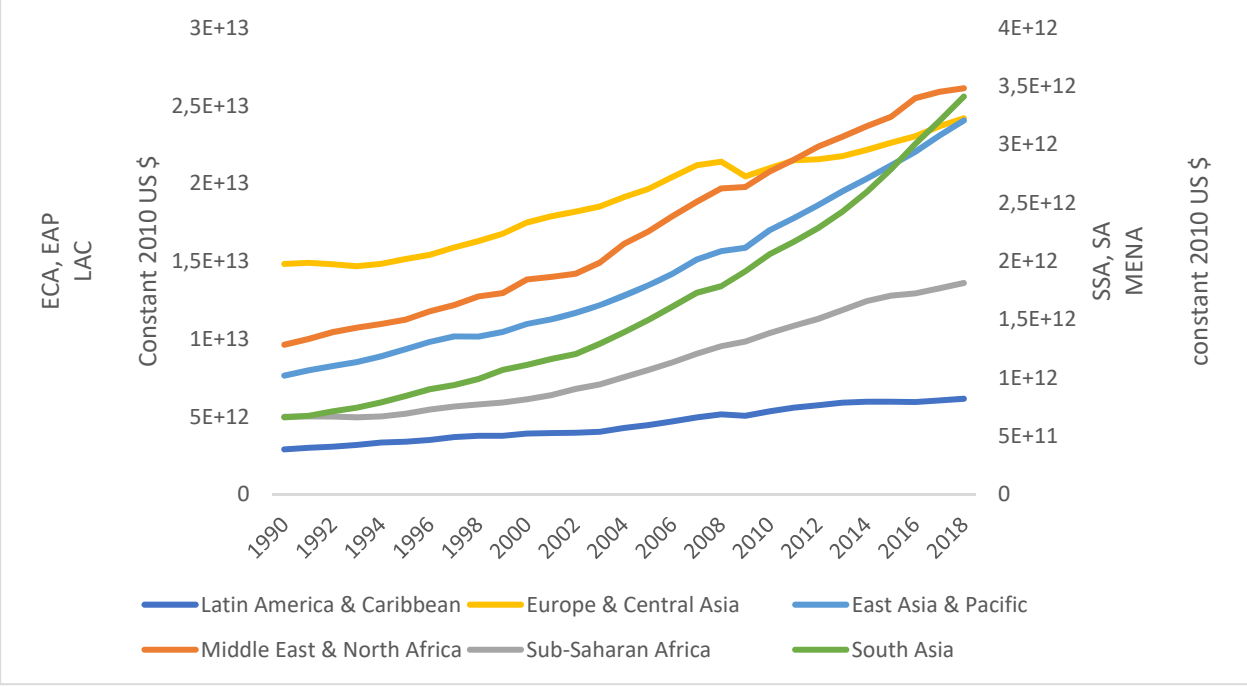
Compared to other regions (Tab.4), East Asia and the Pacific are the only regions where developed countries' social-economic indicators are catching up. For instance, literacy rate and life expectation at birth were close to Europe and Central Asia. For some literature, this is mainly explained by the persistent higher economic growth by some countries in the region like Korea, Malaysia, Singapore, Taiwan, Indonesia and the Philippines. Despite the overall continuing economic growth of 2.3 % in 2019, socio-economic indicators (Table 3 and 4) show that the SSA region is still poverty-stricken. Hence the necessity to explore other areas susceptible to reducing poverty, for instance, financial inclusion.

4.3. Economic, Energy and Environmental ecosystem comparison in different regions

Figure 1 illustrates the evolution over time of the gross domestic product. As the figure shows, the GDP increased more than 300 % in the East Asia Pacific region in less than three decades until reaching almost the same level of Europe Central Asia in 2018. The increase in economic growth in the area comes with a cost such as an increase in the demand for energy which may be the cause behind the speedy rise in energy consumption and CO2 emission in the three decades in the region. For instance, from 1990 to 2018, energy consumption (Fig.2) and CO2 emission (Fig.3) increased more than 300%. Compared to the Europe Central Asia region, there have been more than a 150 % increase in the last three decades. The energy consumption in that part of the world has been stable. From 1992 to 2019, there was less than a 2% increase in energy consumption. It can be noticed that there was a drop in energy consumption in Europe & Central Asia during the financial crisis from 2008 to 2010. The same situation is observed in Figure 1; there is a remarkable drop in economic activities during the financial crisis. Regarding CO2 emission, Europe Central Asia is one of the only regions where the slope decreases significantly by almost 30% from 1990 to 2019.

Figure 1: Evolution of Gross Domestic Product





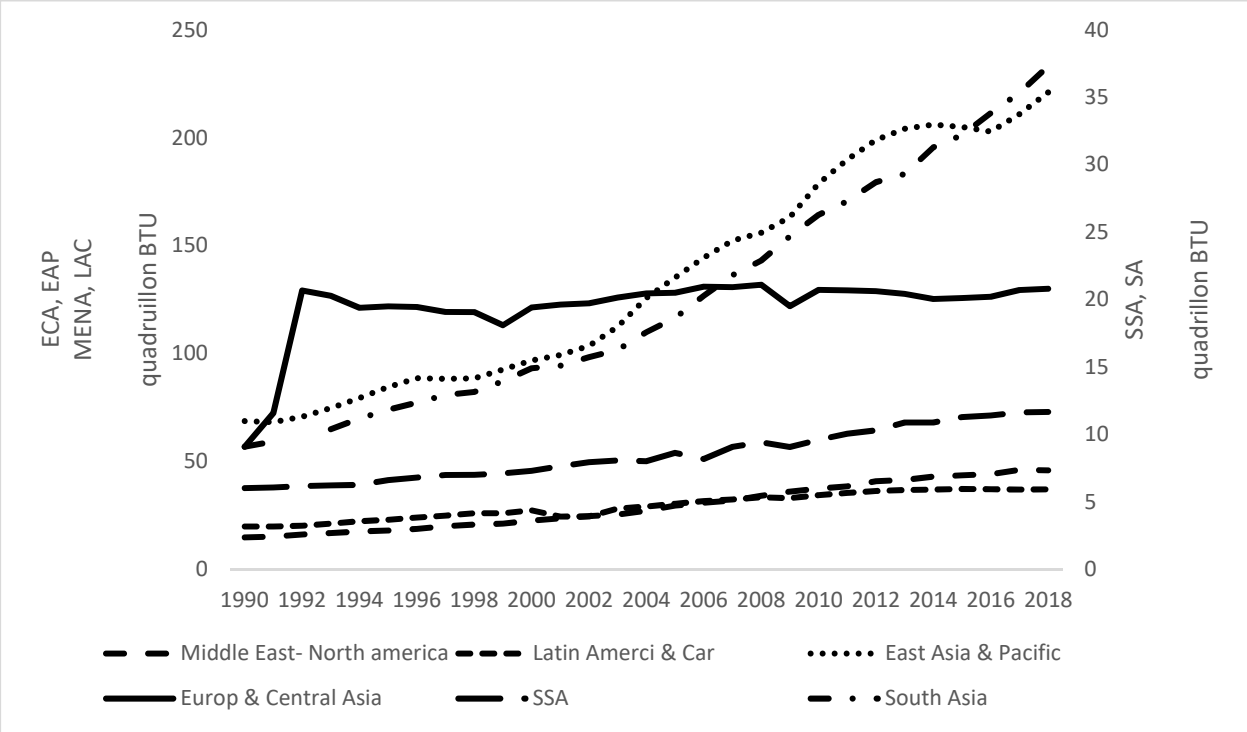
Source: World Development Indicators (WDI)

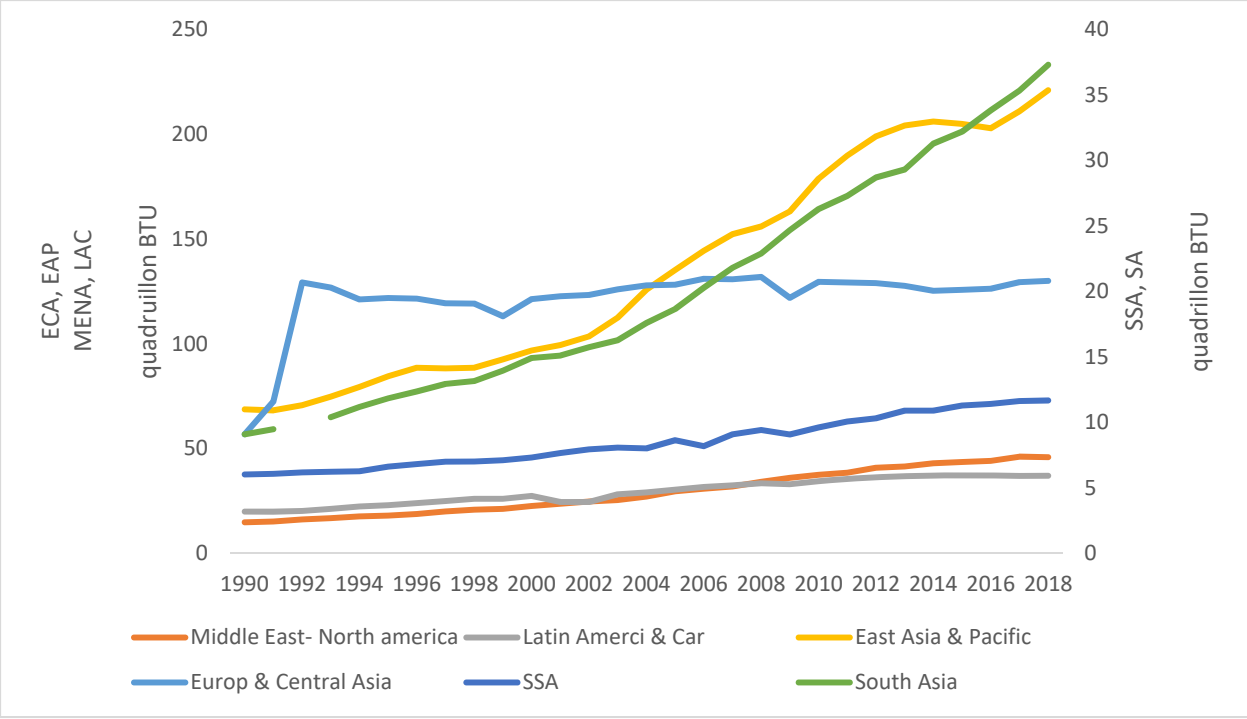
Several reasons might explain the stability in energy consumption over time in Europe Central Asia. Firstly, developed countries have initiated the transition from the manufacturing sector to the services sector, which may help diminish the environmental issues related to the consumption of energy [58]. Secondly, the rapid spread of ICT in the United States and some countries in Europe has led to a decrease in the price of ICT goods, conduce to production and energy efficiency and reduce the greenhouse gas (GHG) [59]. Lastly, the switch to renewable energy in that part of the world has decreased the CO2 emission. Besides East Asia & Pacific and Europe Central Asia regions, Figure 2 has shown a rapid increase in energy consumption in the Middle East and North Asia region from 14.73 quadrillions BTU in 1990 to 45.8 quadrillion in 2018. In the last three decades, [60] explain the increase in energy consumption and CO2 emission by the fact that the rise in the urban population in the region has come with a lot of challenges, and one of them is the increase in the demand of energy.

Other regions such as SSA, South Asia, Latin America & the Caribbean have demonstrated increased energy consumption. For the simple reason that these regions are constituted by developing and emerging countries, some studies have shown that these countries have increased their energy consumption to support their need to grow and prosper. In SSA, it can also be noticed that energy consumption has been sensitive to the financial crisis from 2008 to 2010. The causal direction between energy consumption and economic growth is not always uniform between countries and regions. In Sub-Saharan Africa, economic growth drives energy consumption in countries like DRC. While in countries like Kenya or South Africa, energy consumption drives economic growth [61]. In terms of CO2 emission, Sub-Saharan Africa is still the lowest region to produce CO2 emission (Figure3). Compared to industrialisation and urbanisation, energy consumption is still a significant cause of CO2 emissions [62].

On the other hand, we cannot ignore the speed at which energy consumption has increased in South Asia until reaching the same level as LAC in 2018. The same trend is observed in figure 1. In 1990 the GDP in South Asia countries was almost the same as the one in SSA, but from 2003 we observed a gradual increase until reaching the same level as the one in the LCA region in 2018.

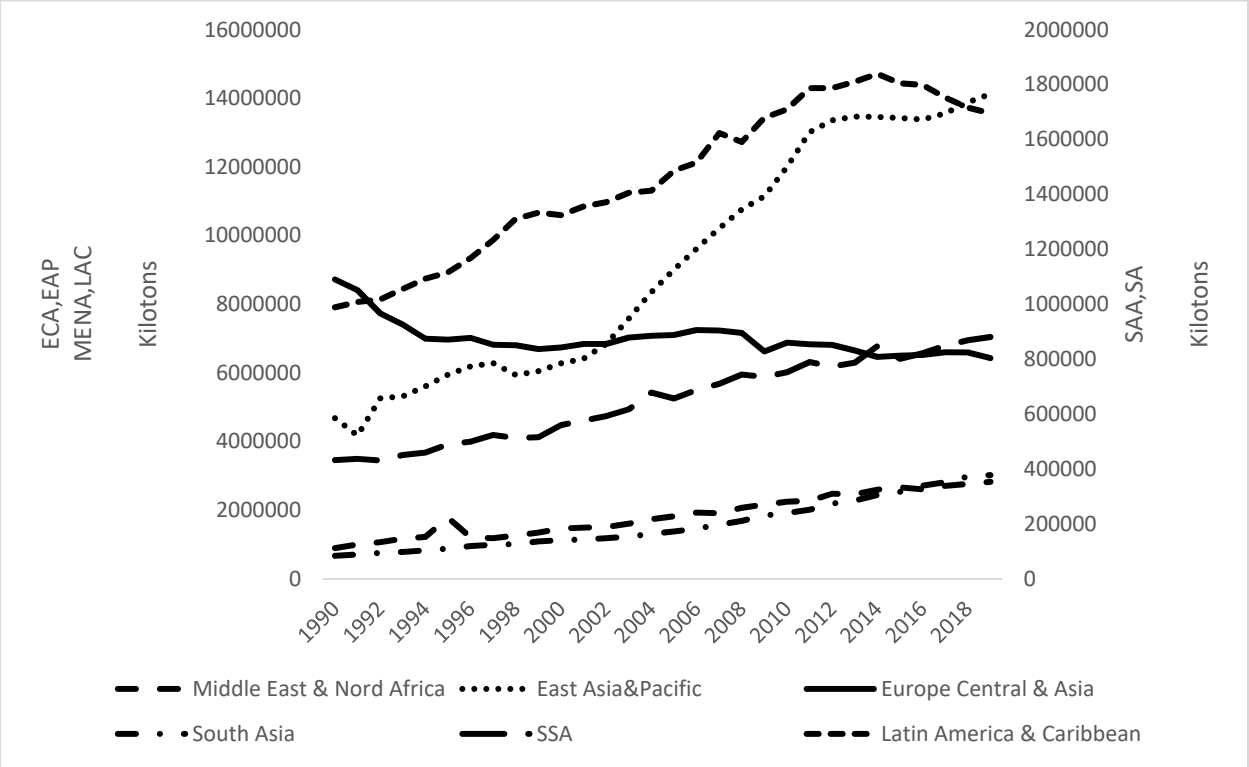
Figure 2. Evolution of Energy consumption

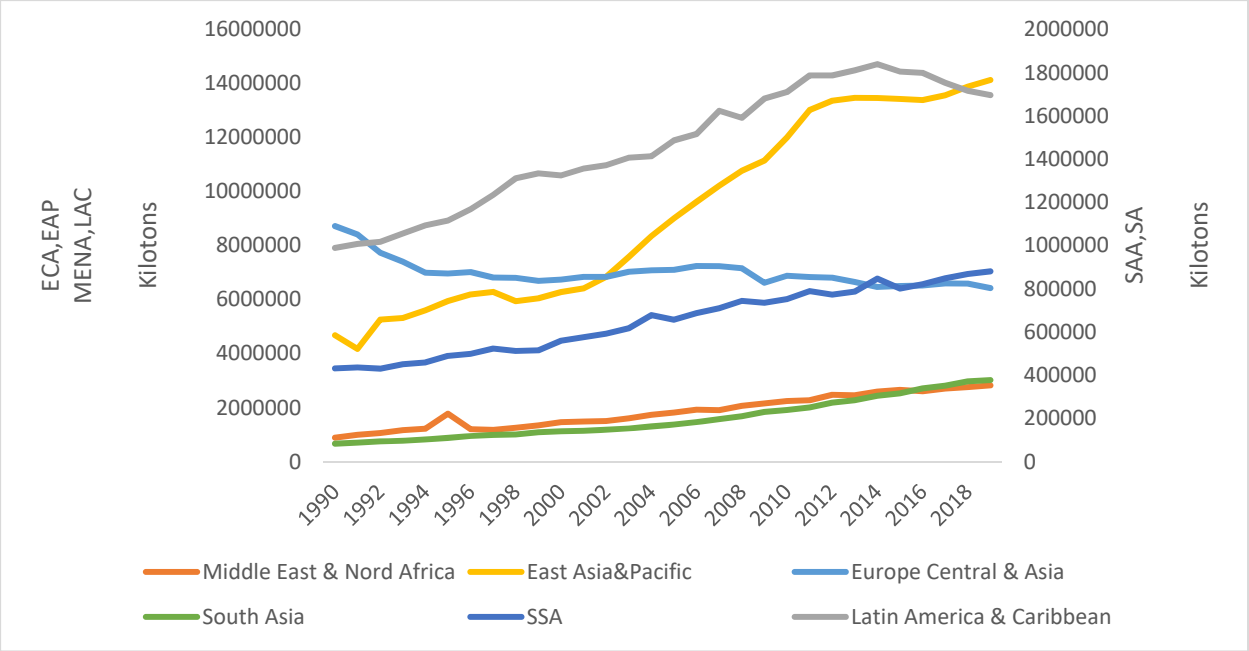




Source: Human Progress

Figure 3: Evolution of CO2 Emission





Source: Human Progress

Empirical researches show that the growth in some countries of the South Asia region such as Pakistan, India, Sri Lanka, Bangladesh and Nepal have increased energy consumption even though the direction is not almost unanimous among them [63].

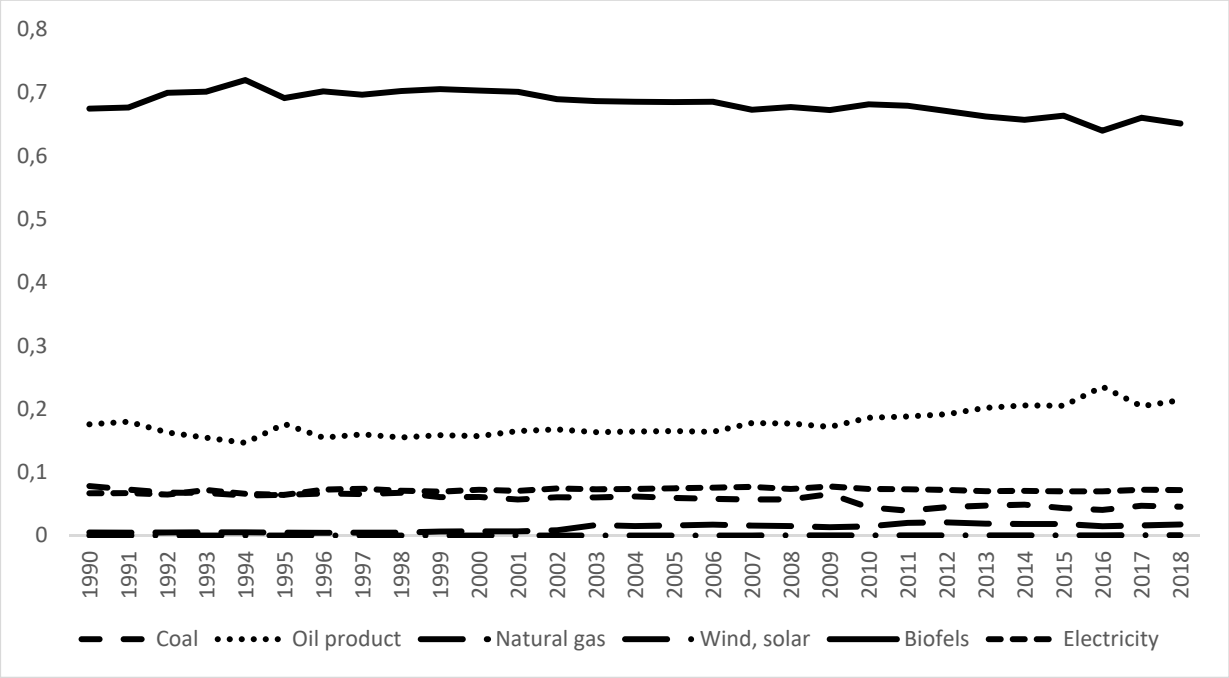
In terms of CO2 emissions, Apart from East Asia & the Pacific, the South Asia region experiences a non-negligible increase in CO2 emissions. In 1990 S.A. regions produced only 668 090 kilotons below Latin America & Caribbean and the Middle East North Asia regions. Three decades later, South Asia has more than 3 020 300 Kilotons. Many factors explained this drastic increase, such as energy consumption, trade openness and population density [64].

Figure 1 shows that Latin America & the Caribbean is the third region that produces the most significant GDP. The studies of [65], [66], mentioned that GDP growth in Latin America & Caribbean region is explained by physical and human capital accumulation and a significant improvement in institutions and policy reforms. Contrary to GDP growth, energy consumption in Latin America & Caribbean region has increased more slowly than in other areas like the Middle East, North Asia, and South Asia. In 1990 energy consumption was higher than Middle East, North Asia and South Asia regions. Three decades later, Latin America & the Caribbean is the lowest energy consumer region after SSA. This might suggest that the economic growth does not come with energy consumption in Latin America & Caribbean region. This is going the same line as the study's conclusion by [67] which finds that economic growth has not been driven by energy consumption in the Latin America Caribbean region. Concerning CO2 emissions, the same has been observed in Figure 3. In 1990, CO2 emission in Latin America & Caribbean was higher compared to Middle East North Asia and South Asia until to start decreasing from 2003 till the end of the period. When we resemble closely at how the energy consumption and CO2 evolve, it shows that these two factors move almost the same even though from 2015, CO2 decreases significantly. The Energy-Environmental Kuznets Curve might explain that the study of [68] has not found the hypothesis relevant in the Latin America Caribbean region. In addition, the study of [67] finds a negative impact of economic growth on carbon emissions.

Figure 4 illustrates the share to total final energy consumption source in Sub-Saharan African countries from 1990 to 2015. The figure shows that Biofuels and Oil products constitute Sub-Saharan Africa's significant share of energy consumption sources of 65% and 21%, respectively, in 2018. As Figure (4) shows, total Biofuels energy consumption share and the share of Oil products move in the opposite direction. Meanwhile, Biofuels energy consumption share decreased by almost 4 % from 1995 to 2018. The total share of oil products increased by nearly the same percentage. Apart from the Coal energy consumption share, which shows a remarkable decrease from 2009, other energy consumption sources

seem to be stable. With the rise in economic growth, population, and urbanisation that the continent currently faces, the energy demand is expected to rise.

Figure 4: Share to total final energy consumption in Sub-Saharan Africa

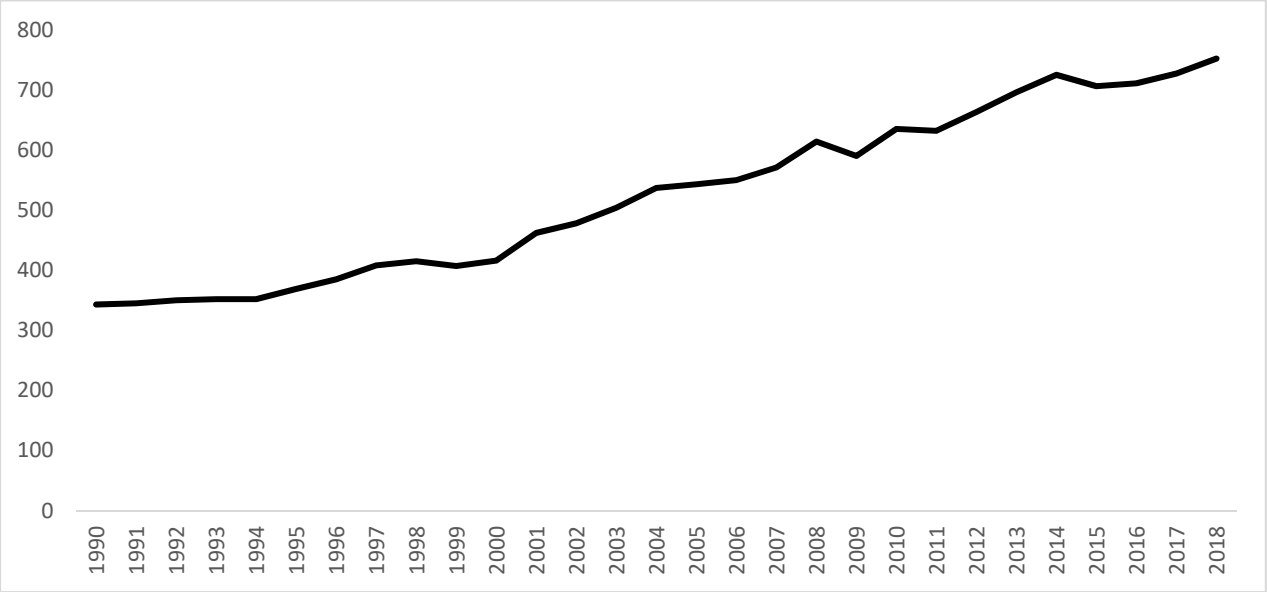


Source: Author's illustration based on IEA data

Hence the necessity to promote other energy sources because there is low energy consumption, and SSA is among regions that are very rich in renewable energy resources. Most of those energy potentials are unexploited, such as sun, wind and wave access [69]. According to the figure, wind, solar, and natural gas are still the lowest energy sources in SSA. Hence the necessity to invest in renewable energy as the solution to CO2 emission issues.

Figure 5 illustrates the evolution of CO2 emission in SSA. As the figure shows, Over the past three decades, Sub-Saharan Africa's CO2 emissions have doubled from 342 mt in 1990 to 752 mt in 2018. Despite this increase, these numbers represent the lowest level compared to other regions in the world. From 2000 until 2014, there has been a persistent increase in CO2 emissions. Meanwhile, between 2008 and 2009, there has been a drop in CO2 emissions due to the economic downturn between 2007 and 2009. This shows how CO2 emissions in SSA are sensitive to economic activities. Some empirical research argues that the persistent increase in CO2 emissions is due to economic growth and population growth.

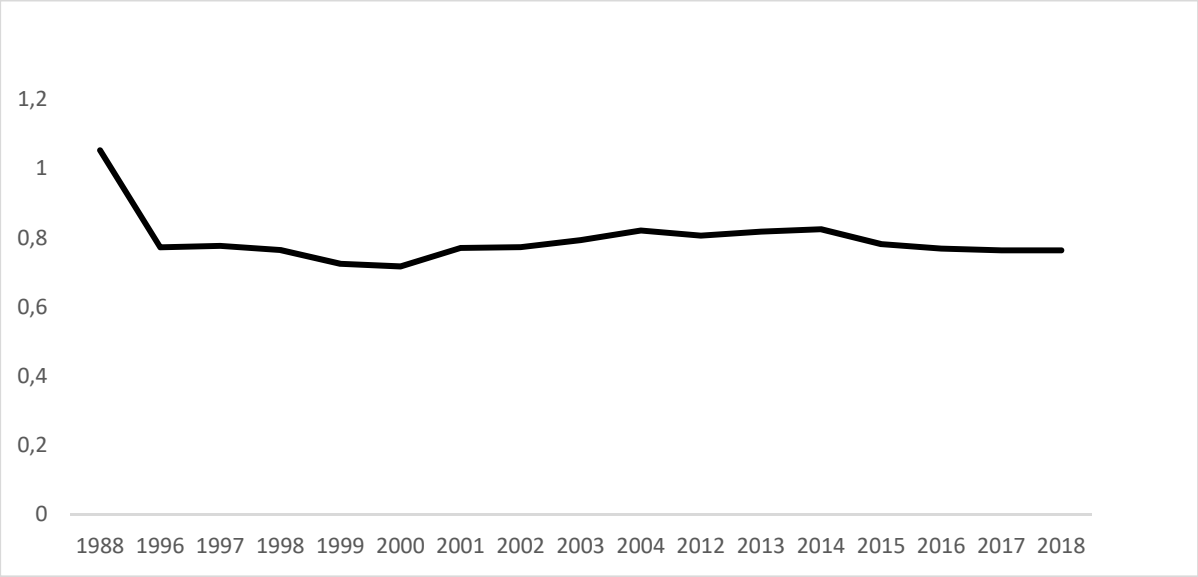
Figure 5: Evolution of CO2 emissions.

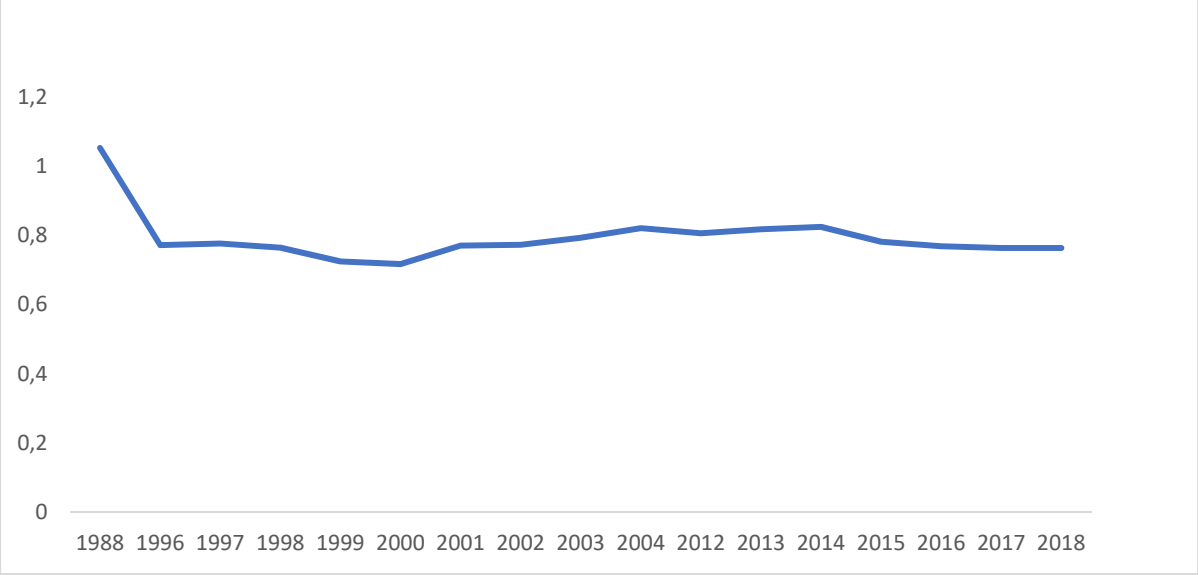


Source: Author's illustration based on IEA data

For instance, Ssali et al. [70] reveal that a 1 % increase in population growth causes an increase in CO2 emission by 0.22%. Figure 6 illustrates the evolution of CO2 emission per capita in Sub-Saharan Africa from 1988 to 2018. As the figure shows, there has been a consistent increase from 0.7171 metric tons per capita in 2000 to 0.8244 metric tons in 2014. In Addition, there is a break in the increasing trend in most of all figures in 2015. The same has been observed in Figure 6. From 2015, CO2 emission per capita starts decreasing till 2018 like a consequence of sub-Saharan Africa's economic activity decelerating due to diverse challenges such as the slowdown of economic activities in China toughen worldwide financial conditions. Internally, the continent has experienced many challenges in the supply of electricity [71].

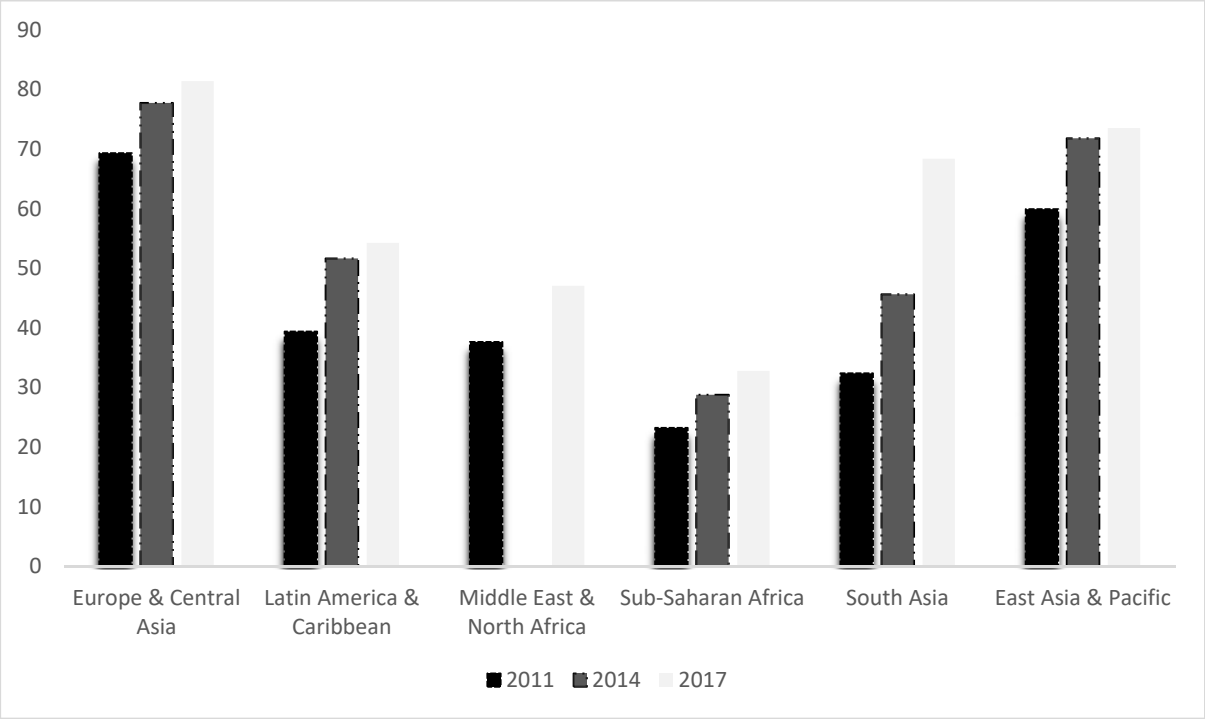
Figure 6: Evolution of CO2 emission per capita

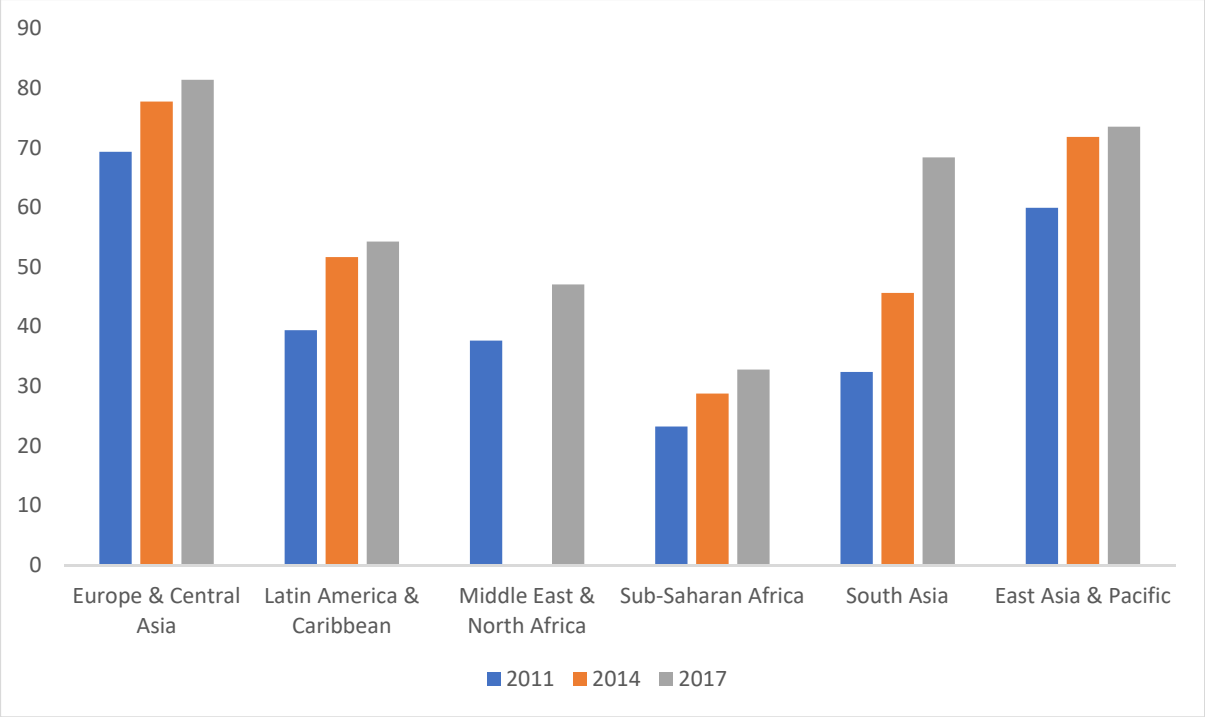




Source: WDI

Figure 7: Financial institution accounts





Source: Global Findex database

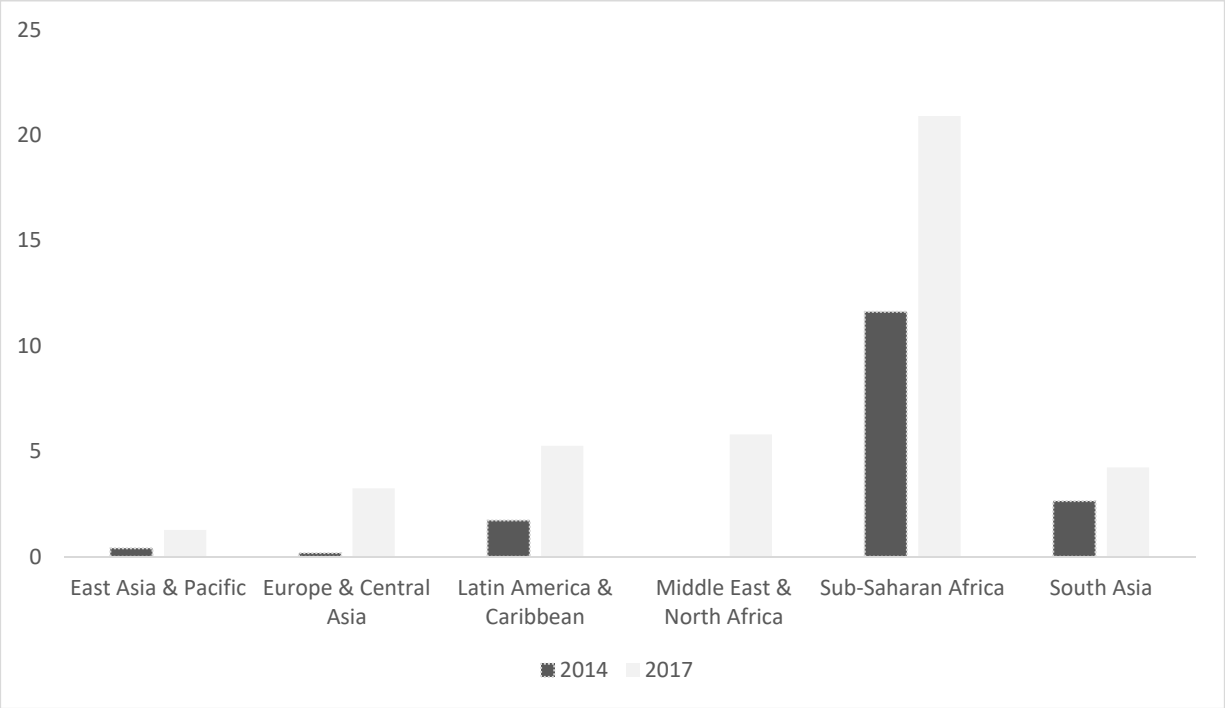
4.4. The current state of financial inclusion penetrations

To reduce poverty in recent years, policymakers have initiated promoting financial inclusion in developing and emerging countries. In the same way, greater accessibility to credit increases self-employment and, thus, reduce poverty level; greater accessibility to deposit services to mobilise savings and improve the availability of affordable insurance products to mitigate the risks are essential for the welfare [72]. The main objective of this section is to describe the current financial inclusion state in comparison to different regions around the world. Figure 7 provides a global view of the percentage of people who claim to have an account at a bank or another financial institution between 2011, 2014 and 2017. According to the figure, Europe and Central Asia have the highest rate among regions where individuals have an account or a financial institution. In 2011, 2014 and 2017, account ownership at a bank or financial institution was 69 %, 77%, and 81%, respectively.

While in East Asia & Pacific countries in 2014, only 59% of people had an account at a bank or financial institution compared to 73% in 2017. There was a massive increase between 2014 and 2017 in the South Asia region. For instance, in 2011, only 32 % of the population had an account at a financial institution, but six years later, the percentage of people who have had an account was 68%. This represents an almost 100% increase. Again, SSA is the lowest region regarding the percentage of people who have an account at a bank or a financial institution. In 2011 only 23 % of the population had an account at a bank or a financial institution compared to 32% in 2017. The same patterns are observed in the Middle East North Asia region, constituting developing countries. Less than 50% of people have an account at a bank or a financial institution. The under-development of financial inclusion in that part of the region might be due to poverty, the lack of regulations and poor infrastructures.

To fill the financial inclusion rate gap in regions like SSA, the Middle East, North Asia, Latin America & the Caribbean, advanced technology has been adopted with a mobile phone to access financial services.

Figure 8: Mobile money account

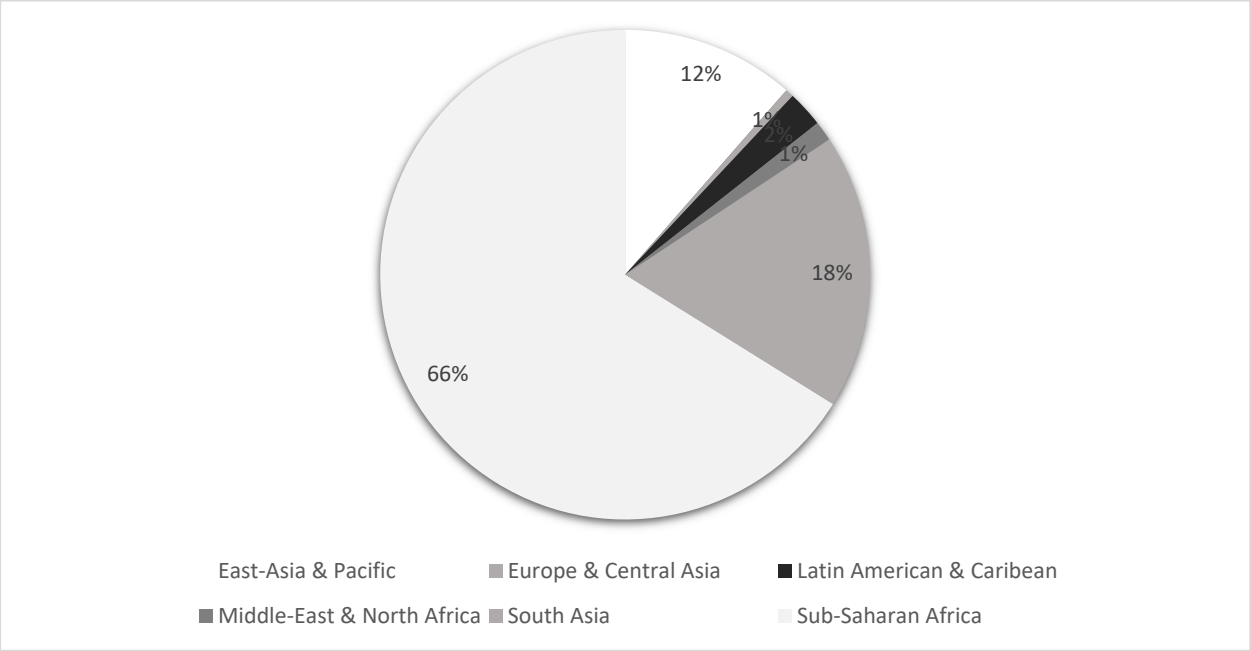


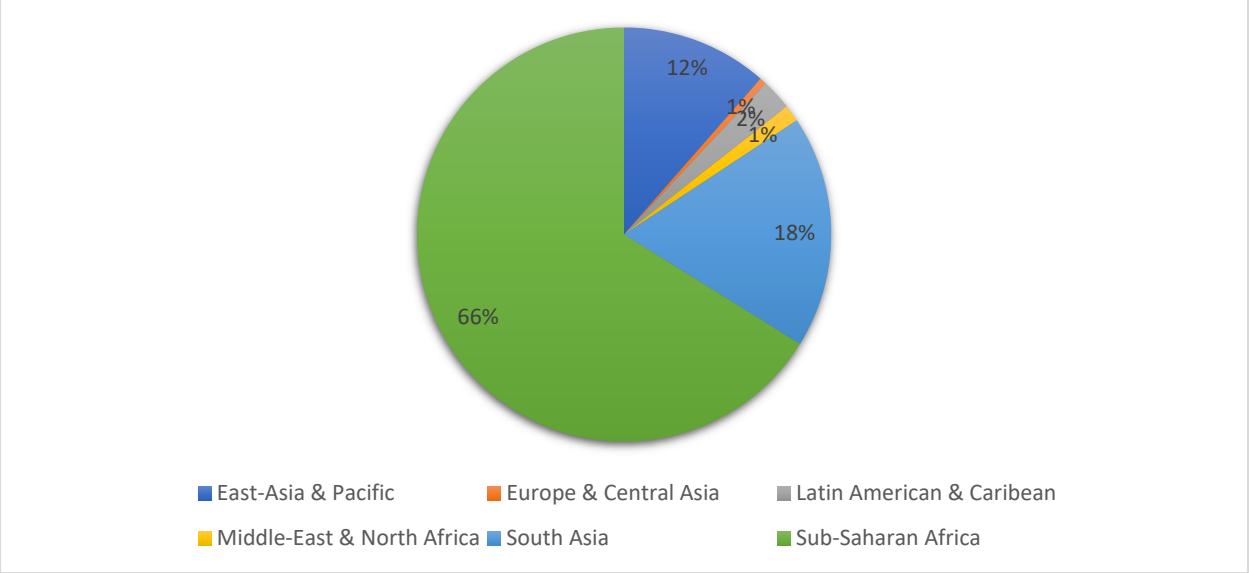
Source: Global findex database

Figure 8 highlights the state of mobile money accounts in different world regions. As illustrated in the figure, the highest utilisation of mobile money is in SSA. The rate almost doubled from 11% in 2014 to 20% in 2017. Hence in 2017, nearly 20% of the population had a mobile money account. While in the Middle East, North Asia, Latin America, Caribbean regions, almost 6% and 5% of the population had a mobile money account in 2017. Only 4% of the population has a mobile money account in South Asia. This is quite clear that only in regions where we find a lot developing countries have a high rate of mobile money account. For instance, East Asia & Pacific and Europe & Central Asia, dominated by developed and emerging countries, have 3% and 1% of the population using mobile money accounts.

In terms of mobile money transactions, GSMA (2019) report mentions that in 2019 mobile money transactions has increased almost by 20%, reaching $690 billion. Figure 9 shows the transaction values of mobile money. SSA counts 66 % of the total transaction value is $456 billion, representing almost 26 % of the real GDP of the Sub-Saharan Africa region. They are followed by the South Asia and East-Asia & Pacific regions which count 18 % and 12% of the total transaction values. This strong growth shows the capacity of the mobile money platform to digitise an increasing amount of capital.

Figure 9: Mobile money transaction value





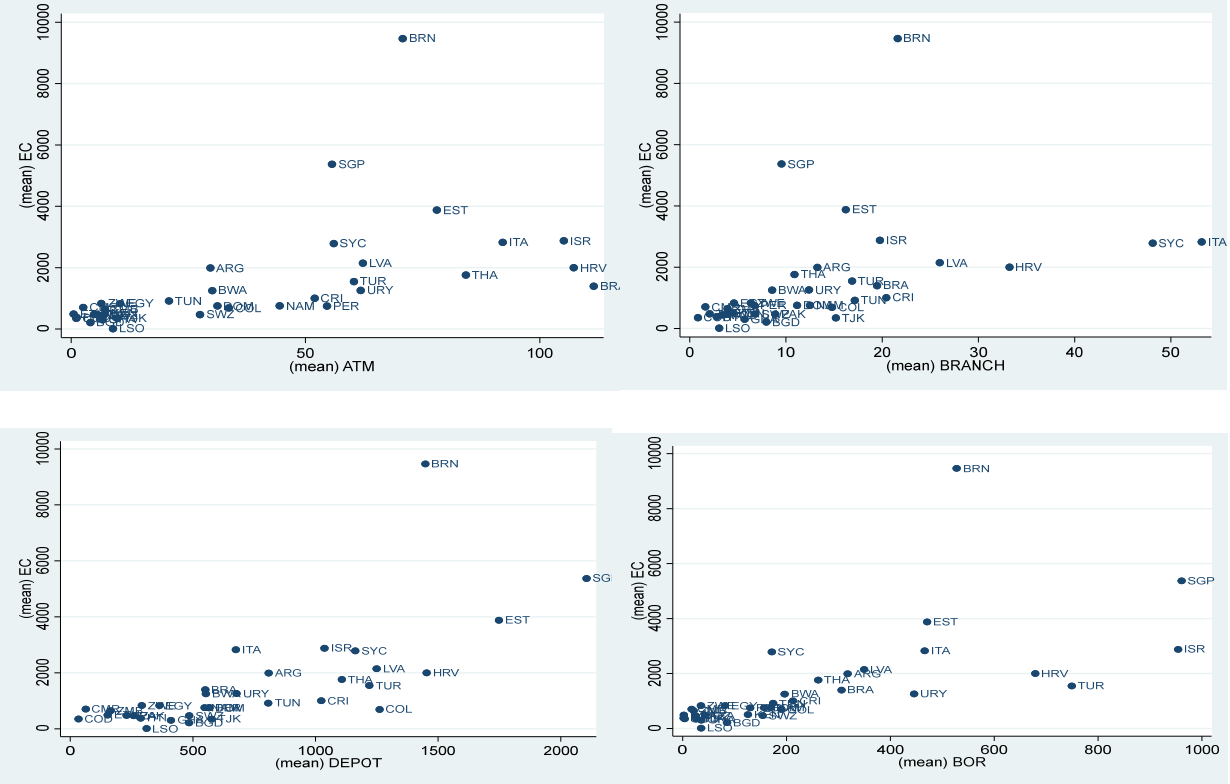
Source: GSMA 2019

4.5. Correlation between financial inclusion and technology vis-à-vis to energy consumption

A developed and inclusive financial sector plays a significant role by mobilising savings and providing easy access to funds, consequently rendering growth [8]. All of this may somehow require energy as the key to producing goods and services. Thirty-nine countries are used to test the correlation between energy

consumption and financial inclusion proxies between different regions. Among these 39 countries, we have 17 countries SSA, 7 ECA countries, 7 LAC countries, 4 MENA countries and 2 S.A. countries. Overall, Figure 10 suggests that higher financial inclusion proxies are associated with higher energy consumption. It appears that the relationship between the number of ATMs per 100,000 adults remains positive, linear, but moderate. SSA countries such as Congo, Dem, Rep (COD), Guinea (GIN), Cameroon (CMR), Tanzania (TZA), Uganda (UGA), Madagascar (MDG), Zambia (ZMB) and Zimbabwe (ZWE) are in the lower left-hand corner of the figure.

Figure 10: Relationship between energy consumption and financial inclusion proxies



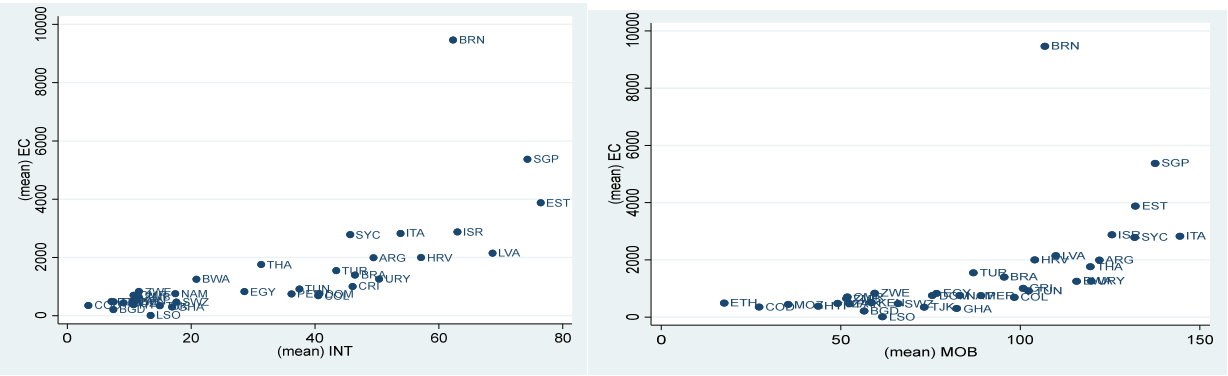
Source: Global Findex database

This shows that most developing countries in SSA and S.A. have fewer ATMs per 100,000 adults and a lower energy consumption rate. There are some exceptions for countries like Namibia (NAM), Botswana (BWA), and Swaziland (SWL) have a higher number of ATMs per 100 000. Brunei and Singapore are outliers. In general, higher-income countries in the ECA tend to be at the figure's right hand. Brazil must have the highest number of ATMs per 100 000. Thus, a higher number of ATMs per 100 000 adults in those countries is most of the case associated with higher energy consumption per capita. The same is

observed with the number of BRANCH per 100 000 adults. Higher-income countries in the ECA such as Italia (ITA), Croatia (HRV), Latvia have the highest BRANCH per 100 000 adults. Seychelle has witnessed a higher number of BRANCH and ATMs among SSA countries in the continent. This might be because Seychelle has the highest GDP per capita in the continent. People tend to use financial services due to the higher domestic revenue.

In terms of the number of DEPO per 1000 adults, EAP countries like Singapore (SGP) and Thailand (THAN) show a higher number of adults per deposit. For instance, Singapore has more than 2000 deposits per 1000 adults. For this part of the world, higher and more stable economic growth might cause an increase in the deposit per 1000 adults. Other Latin American and Caribbean like Colombia (COL) and Costa-Rican (CRI) have also shown higher deposits per 1000 adults. Finally, among the financial inclusion proxies, BOR per 1000 adults seems to have also a lower access number across countries. On average more than 900 per 1000 adults have access to a loan in countries like Singapore and Israel. Only eight countries like Singapore, Israel, Turkey, Croatia, Brunei, Estonia, Italia and Uruguay out of 39 countries of the sample have more than 400 people that have access to borrow per 1000 people while in terms of number of BRANCH per 100 000, only four countries like Italia, Seychelle, Croatia and Latvia that have on average more than 25 branches per 100,000 per adults. The number of branches per 100 000 adults and borrowers per 1000 adults constitutes the principal obstacle barrier to financial inclusion.

Figure 11: Relationship between energy consumption and technology



Source: WDI

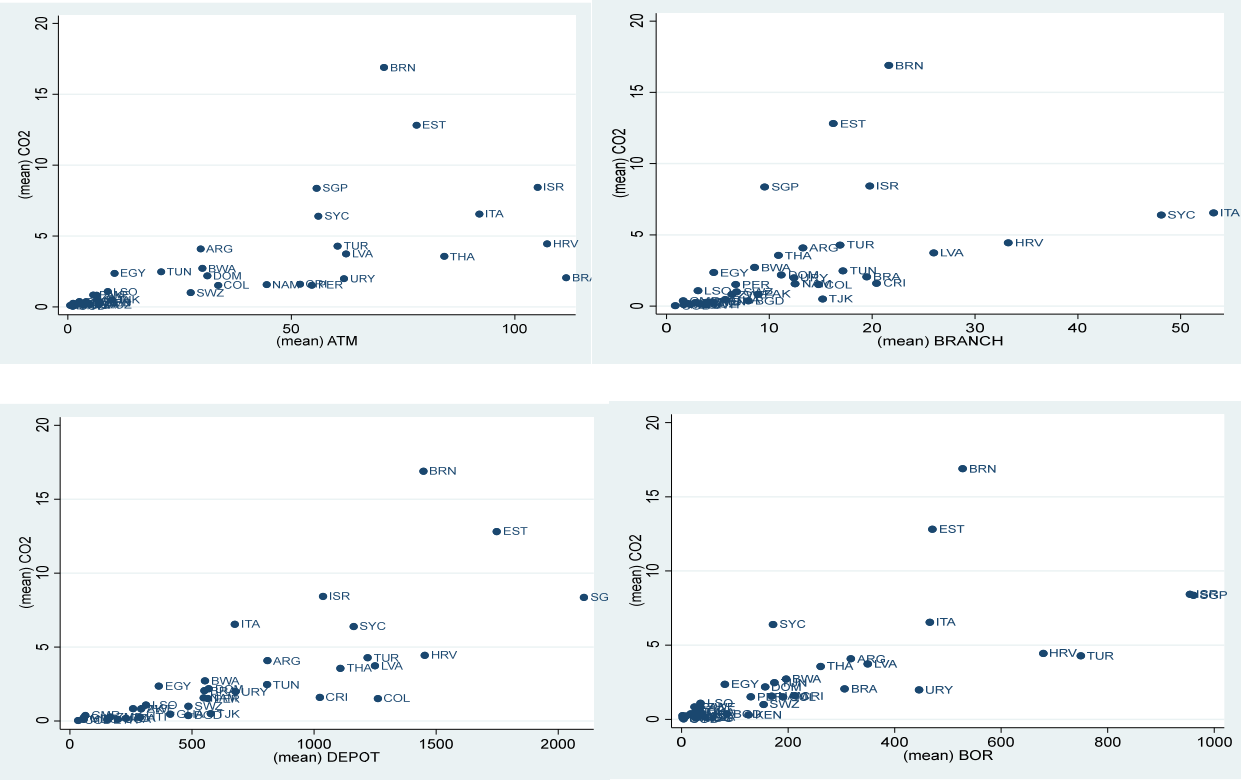
Figure 11 illustrates the correlation between energy consumption and technology. In this case, internet users per 100 people and mobile phones are used as proxies for technology. According to the figure, the correlation between energy consumption per capita and internet users' subscriptions is positive, linear and moderate weak. On the other hand, there is a correlation between energy consumption and mobile

cellular; even though it is not linear and perfect, it is not linear. The figure shows that there has been greater mobile phone penetration globally. Most of the countries in the sample tend to be at the right hand of the figure. This is the same even for SSA countries; they tend to be at the right-hand corner of the figure due to the continent's higher mobile phone penetration rate while the energy consumption per capita is still low. This might be the reason for this low correlation. In terms of internet users, most SSA countries show a low number of internet users per 1000 people compared to other regions.

4.6. Correlation between financial inclusion and technology vis-à-vis to CO2 emission

As we mentioned early, DFI may affect the environment indirectly by their pass-through effect on economic growth and poverty reduction. Like in energy consumption vs financial inclusion, 39 countries are used to test the correlation between CO2 emission and financial inclusion. In general, figure 12 suggests a higher number of ATMs per 100 000 adults, BRCH per 100 000 adults, DEPO per 1000 adults and BOR per 1000 adults are associated with higher CO2 emissions. Among these financial inclusion proxies, the number of ATMs per 100 000 tends to show a positive, linear and moderate correlation with the CO2 emission. Again, most SSA countries are in the lower left-hand corner of the figure, with some exceptions for countries like Namibia (NAM) and Botswana (BWA). This illustrates that most developing countries in SSA have a lower number of ATMs per 100,000 adults and lower CO2 metric tons emission per capita. In terms of CO2 metric tons per capita, higher and upper-income countries such as Brunei, Estonia, Singapore, Israel, Croatia, and Italia have the highest CO2 emissions. The same is observed with other financial inclusion proxies, BRANCH per 100,000 adults, DEPO per 1000 adults, and BOR per 1000 adults show a positive, linear, and moderate relationship with CO2 emissions.

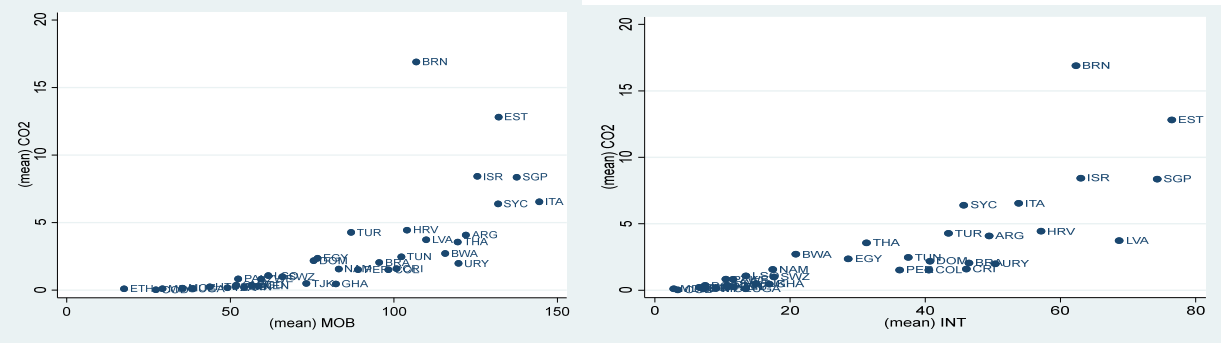
Figure 12: Relationship between DFI VS Environments



Source: Global findex database

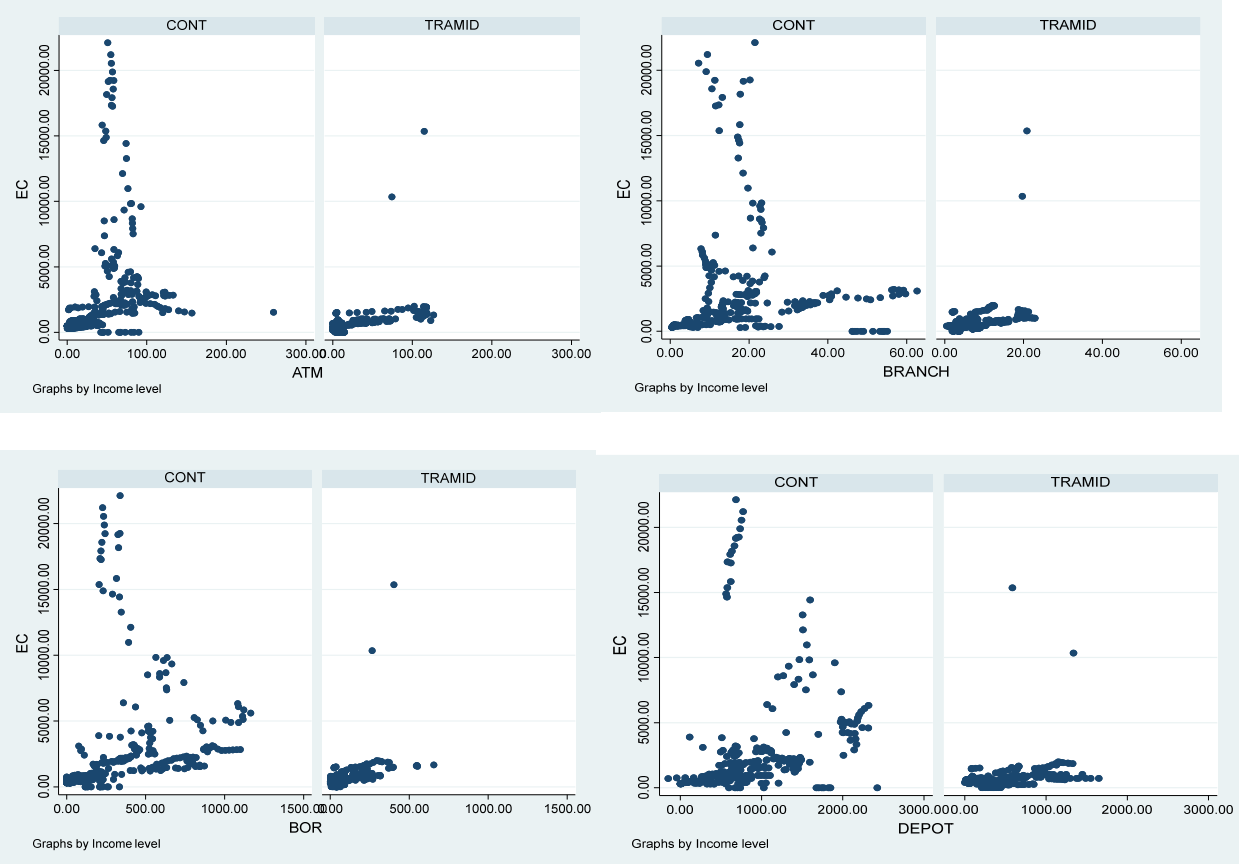
Figure 13 illustrates the correlation between CO2 emission and technology proxies. According to the figure, the same has been observed in Figure 10 regarding the number of mobile phones per 100 people. The correlation between mobile telephones per 100 people and CO2 emission is not linear. In general, there is a positive and moderate correlation between CO2 emission and technology proxies. Contrarily to financial inclusion proxies, the correlation between CO2 emission and the number of mobiles per 100 people shows that most SSA countries tend to be at the lower right-hand corner of the figure. This is explained by the proliferation of mobile phones all over the region. On the other hand, the correlation between CO2 emission and internet users per 100 people shows that many SSA countries are at the lower left-hand corner of the figure while most of Europe & Central Asia countries are on the figure's right hand. This shows how the number of internet users per 100 is still lower than other regions dominated by higher-income countries like Europe & Central Asia.

Figure 13: Relationship between CO2 emission and technology



Source: WDI

Figure 14: Relationship between energy consumption and financial inclusion proxies by country income categorisation



Source: Global findex database

Figure 13 shows how the change in the economic conditions of different countries has influenced the slope of the relationship between energy consumption and financial inclusion proxies during the study period. 16 countries out of 40 have transformed from Low to Middle-income countries, 24 out of 40 have no transition, and 0 countries have transformed from Middle to High-income during the study period. From our observation, "Countries with no Transition" (CONT) are constituted mainly by Europe & Central Asia, East-Asia & Pacific, Middle East & Nord America and SSA countries. In contrast, only Latin America & the Caribbean and South Asia are mainly constituted by "Countries Transitioning towards Middle Income" (TRAMID). The group of CONT fails to produce a suitable slope because the gap between energy consumption and financial inclusion proxies is significant between countries in the group. On the other hand, TRAMID seems to have a steep slope, which means a change in energy consumption is associated with positive changes in financial inclusion proxies. Still, the period is concise to capture the whole slope. Brazil is the outlier in TRAMID as the country has almost the same financial inclusion proxies compared to Europe& Central Asia countries.

5. CONCLUSION

Given the persistent increase in energy consumption and CO2 emissions over the last decades, it becomes urgent to analyse channels in which economic activities are susceptible to increase energy consumption and, by the same time, CO2 emissions for the simple reason that an important share of energy consumption is constituted by fossil energy, particularly oil, coal and gas which is considered as a main responsible to CO2 emissions. On the other hand, policymakers, academic researchers and shareholders have initiated different economic policies to ensure inclusive economic growth and end poverty. One of the most well-known is financial inclusion. New technology such as mobile banking, mobile money and internet banking have helped spread financial inclusion, especially in emerging countries. Therefore, a financial sector that is deep but also provides broader access to financial services is likely to be associated with energy consumption and CO2 emission through the effect on inclusive economic growth. This study aims to evaluate the expansion of innovative digital services and financial inclusion on energy consumption and environment in different country groups according to geographical position. Based on the analysis, regions constituted by countries transitioning towards middle income have increased digital financial inclusion, energy consumption and CO2 emission. Hence, the financial sector must provide financial services capable of stimulating the shift from nonrenewable energy to renewable energy. On the other hand, for government to create political stability and prioritise the development of a robust, trustworthy and independent financial sector.

Most developing and emerging countries, particularly in SSA, South Asia and Pacific Asia, have adopted advanced financial technology with the help of mobile phones to include a sizeable working-age population in the financial system conducive to economic growth and to reduce poverty. The primary assumption is based on the fact that digital financial inclusion influences energy consumption and the environment by their pass-through effect on economic growth. In other words, financial inclusion is accompanied by improving economic activities and economic development, which may affect energy consumption decisions and the environment. Based on the World Bank data, developing countries are responsible for 62 % of the global total carbon dioxide emission. The main challenge faced by these countries in the current green development tendency is to what extent an increase in fossil energy is considered the principal agent of CO2 emissions negatively affecting the environment.

Regarding socio-economic indicators such as employment, literacy, inequality, education, income, access to electricity and adequate sanitation, it has been shown that East Asia and the Pacific is the only region where social-economic indicators are catching up to these in developed countries. At the same time, Sub Saharan African and South Asia countries are still stagnating in poverty. Hence, it is necessary to explore other ways to encourage economic growth and reduce poverty through financial inclusion while limiting CO2 emissions. Considered a principal cause of CO2 emissions, the economic growth in East Asia and the Pacific region comes with a cost such as an increase in the demand for energy which may be the cause behind the speedy rise in energy consumption and CO2 emission in the three decades in the region. Middle East and North Asia region has also shown a pretty rapid increase in energy consumption favourite by the urbanisation of the population. In addition, SSA, South Asia, Latin America & the Caribbean have demonstrated a non-negligible increase in energy because these regions are constituted by developing and emerging countries. Some studies have shown that these countries have increased their energy consumption to support their need to grow and prosper. SSA is the lowest energy consumer region compared to other regions, consequently the lowest region to produce CO2 emission. SSA should explore other sources to increase energy production to support economic growth and urbanisation, considering the energy sources' potentiality.

Regarding the percentage of people who claim to have an account at a bank or another type of financial institution, Europe & Central Asia followed by East Asia & Pacific region had the highest percentage, respectfully 81% and 73% in 2017. Most of these regions are constituted by developed and emerging countries. Again, SSA is the lowest region where people have an account at a bank or a financial institution. In 2017, only 32 % of people claimed to have an account at a bank or a financial institution. On the other hand, the highest utilisation of mobile money is in SSA, 20 % in 2017. Only 3% and 1% of the population have mobile money accounts in East Asia & Pacific and Europe & Central Asia. Hence,

we find a high rate of mobile money account in regions dominated by developing countries. Concerning the correlation between financial inclusion and energy consumption, the results financial suggests that higher financial inclusion proxies are associated with higher energy consumption.

In contrast, the relationship between technology proxies and energy consumption is not always linear. Most developing countries in SSA and S.A. are in the lower left-hand corner of the figure, except for the number of mobile phones per 100 people. This is due to the proliferation of mobile phones in these countries. Again, higher financial inclusion proxies are associated with higher CO2 emissions. Furthermore, the same has been shown with technology proxies.

Given the results and the current green development tendency, any policy encouraging financial inclusion should also consider energy consumption and CO2 emissions. Despite the progress in DFI with the help of mobile phones, other financial inclusions proxies are not developed as expected in the Sub-Sahara African region. Hence the need to have an adequate political strategy to include a large majority of the population in the financial system using mobile phones all over the area. Especially on one side, financial inclusion through mobile phones has been proven in many countries like Kenya, Rwanda and Ghana. On the other side, the correlation between mobile phones and energy consumption is not linear, especially for Sub-Saharan African countries. In future research, we plan to evaluate the impact of DFI to energy in these different income groups so the changes in classification will be more apparent there.

References

[1] IEA, "Global Energy & CO2 Status Report: The latest trends in energy and emssions in 2018," International Energy Agency, Paris, 2019.

[2] Y. Keho, "What drives energy consumption in developing countries? The experience of selected African countries," *Energy Policy,* vol. 91, pp. 233-246, April 2016.

[3] S. Kergroach, "National innovation policies for technology upgrading through GVCs: A cross-country comparison," *Technological Forecasting and Social Change,* vol. 145, pp. 258-272, August 2019.

[4] G. Grossman and A. Krueger, "Environmental Impacts of a North American Free Trade Agreement," *National Bureau of Economic Research,* pp. 1-39, November 1991.

[5] K. Ito, "CO2 emissions, renewable and non-renewable energy consumption, and economic growth: Evidence from panel data for developing countries," *International Economics,* vol. 151, pp. 1-6, October 2017 2017.

[6] F.-P. Sakiko, "Sustainable development goals," in *The Oxford Handbook on the United Nations (2nd edn)*, Oxford, The Oxford University, 2018, pp. 764-778.

[7] W. B. Group, Global Financial Development Report 2014 : Financial Inclusion, Washington DC: World Bank publication, 2013 Nov 7.

[8] Alimi and R. Santos, "Financial deepening and economic growth : A System GMM Panel Analysis with application to 7 SSA countries," *Munich Personal RePEc Archive,* pp. 1-11, 2015.

[9] GPIF, "2014 Financial Inclusion Action Plan," Global Partnership for Financial Inclusion, New York, 2014.

[10] A. Demirgüç-Kunt, L. Klapper, D. Singer, S. Ansar and J. Hess, "The Global Findex Database," World Bank Group, Washington, 2017.

[11] W. Bank, "Global Financial Developement 2014 Report," World Bank Group, Washington, 2014.

[12] R. Mishra, D. Bhandia, S. V. Vinitha and S. S. Bose, "Financial Inclusion and Financial Stability: Are They Two Sides of the Same Coin?," Reserve Bank of India, Mumbai, 2011.

[13] M. Sarma and J. Pais, "Financial Inclusion and Development," *Journal International Developement ,* vol. 23, pp. 613-628, 2010.

[14] O. Kabakova and E. Plaksenkov, "Analysis of factors affecting financial inclusion: Ecosystem view," *Journal of Business Research,* vol. 89, pp. 198-205, 2018.

[15] M. K. Mahalika, S. Babu, N. Loganathanc and M. Shahbazd, "Does financial development intensify energy consumption in Saudi Arabia?," *Renewable and Sustainable Energy Reviews,* vol. 75, p. 1022–1034, 2017.

[16] R. Goldsmith, "The Comparative Study of Economic Growth and Structure," in *Financial Structure and Development*, Yale University Press, New Haven, 1969, pp. 114 - 123.

[17] E. Shaw, Financial Deepening in Economic Development, New York: Oxford University Press, 1973.

[18] R. G. King and R. Levine , "Finance, entrepreneurship, and growth," *Journal of Monetary Economics,* vol. 32, no. 3, pp. 513-542, 1993.

[19] R. Joan, "The Generalisation of the General Theory," in *The generalisation of the general theory and other essays*, London, Springer, 1979, pp. 1-76.

[20] F. Knight, Economic organization, New York: Transaction Publishers, 2013.

[21] J. Schumpeter, "The theory of economic development," *Transaction Publishers,* p. 244, 1982.

[22] D.-W. Kim, J.-S. Yu and K. Hassan, "Financial inclusion and economic growth in OIC countries," *Research in International Business and Finance,* vol. 43, pp. 1-14, 2018.

[23] N. Apergis and J. E. Payne, "Energy consumption and economic growth in Central America: Evidence from a panel cointegration and error correction model," *Energy Economics,* vol. 31, no. 2, pp. 211-216, 2009.

[24] C.-C. Lee, "Energy consumption and GDP in developing countries: A cointegrated panel analysis," *Energy Economics,* vol. 27, no. 3, pp. 415-427, 2005.

[25] R. Inglesi-Lotz, "The impact of renewable energy consumption to economic growth: A panel data application," *Energy Economics,* vol. 53, pp. 58-63, 2016.

[26] S. Farhani and J. B. Rejeb, "Link between Economic Growth and Energy Consumption in Over 90 Countries," *Interdisciplinary Journal of Contemporary Research in Business,* vol. 3, no. 11, pp. 282-297, 2012.

[27] A. Banerjee and . A. Newman, "Occupational Choice and the Process of Development," *Journal of Political Economy,* vol. 101, no. 2, pp. 274-298, 1993.

[28] O. Galor and J. Zeira, "Income Distribution and Macroeconomics," *Review of Economics Studies,* vol. 60, no. 1, pp. 35-52, 1993.

[29] P. Aghion and . P. Bolton, "A Theory of Trickle-Down Growth and Development," *Review of Economic Studies,* vol. 64, no. 2, p. 151–172, 1997.

[30] R. Levine, Beck and A. Demirguc-Kunt, "Finance, Inequality and the Poor," *Journal of Economic Growth,* vol. 12, pp. 27-49, 2007.

[31] S. Neaime and I. Gaysset, "Financial inclusion and stability in MENA: Evidence from poverty and inequality," *Finance Research Letters,* vol. 24, pp. 230-237, 2018.

[32] F. Aportela, "Effects of Financial Access on Savings on Low-Income people," *MIT Department of Economics,* pp. 1-59, 1999.

[33] N. Ashraf, D. Karlan and W. Yin, "Tying Odysseus to the Mast: Evidence from a Commitment Savings Product in the Philippines," *Quarterly Journal of Economics,* pp. 673-697, 2006.

[34] P. Dupas and J. Robinson, "Savings Constraints and Microenterprise Development: Evidence from a Field Experiment in Kenya," *American Economic Journal : Applied Economics,* vol. 5, no. 1, pp. 162-92, 2013.

[35] N. Ashraf, D. Karlan and W. Yin, "Female Empowerment: Further Evidence From a Commitment Savings Product in the Philippines," *World Development,* vol. 38, no. 3, pp. 333-344, 2010.

[36] T. Beck, A. Demirguc-Kunt and M. Martinez, "Reaching out: Access to and use of banking services across countries," *Financial Economics,* vol. 85, no. 1, pp. 234-266, 2007.

[37] T.-H. Le, H.-C. Le and F. Taghizadeh-Hesary, "Does financial inclusion impact CO2 emissions? Evidence from Asia," *Finance Research Letters,* vol. 34, pp. 1-7, 2020.

[38] M. Andrianaivo and K. Kpodar, "Mobile Phones, Financial Inclusion, and Growth," *Review of Economics and Institutions,* vol. 3, no. 2, pp. 1-30, 2012.

[39] T. Beck, H. Pamuk, R. Ramrattan and B. R. Uras, "Payment intruments, finance and development," *journal of Development Economics,* vol. 133, pp. 162-186, 2018.

[40] M. Bittencourt, "Financial development and economic growth in Latin America: Is Schumpeter right?," *Journal of policy Modeling,* vol. 34, no. 3, pp. 314-355, 2012.

[41] Staff Report IMF, "Digital Money Across Borders: Macro-Financial Implications," International Monetary Fund, Washington, D.C, 2020.

[42] T. Zaghdoudi , "Internet usage, renewable energy, electricity consumption and economic growth : Evidence from developed countries," *Economics Bulletin,* vol. 37, no. 3, pp. 1612-1619, 2017.

[43] S. Lange, J. Pohl and T. Santarius, "Digitalization and energy consumption. Does ICT reduce energy demand?," *Ecological Economics,* vol. 176, pp. 1-14, 2020.

[44] M. A. Achachlouei, Exploring the Effects of ICT on Environment Sustainability : From life cycle assessment to complex systems modeling, Stockholm: KTH Royal Institute of Technology, 2015, pp. 1-67.

[45] G. Liu, "Estimating Energy Demand Elasticities for OECD Countries: A Dynamic Panel Data Approach," *Statistics Norway, Research Department,* pp. 3-27, 2004.

[46] P. Sadorsky, "Information communication technology and electricity consumption in emerging economies," *Energy Policy,* vol. 48, pp. 130-136, 2012.

[47] M. Salahuddin and K. Alam, "Information and Communication Technology, electricity consumption and economic growth in OECD countries: A panel data analysis," *Electrical Power and Energy Systems,* vol. 76, pp. 185-193, 2016.

[48] D. Collier, "The Comparative Method," *American Political Science Association,* pp. 106-119, 1993.

[49] R. Inglesi-Lotz and J. Blignaut, "Electricity intensities of the OECD and South Africa: A comparison," *Renewable and Sustainable Energy Reviews,* vol. 16, no. 7, pp. 4491-4499, 2012.

[50] P. Rolffs, D. Ockwell and R. Byrne, "Beyond technology and finance: pay-as-you-go sustainable energy access and theories of social change," *Environment and Planning,* vol. 47, no. 12, p. 2609 – 2627, 2015.

[51] E. Olaniyi and A. R. Osi, "Financial Inclusion and GDP Per Capita in Africa: A Bayesian VAR Model," *Journal of Economics and Sustainable Development,* vol. 8, no. 18, pp. 44-57, 2017.

[52] S. Babu, N. Loganathan and M. Shahbaz, "Does financial development intensify energy consumption in Saudi Arabia," *Renewable and Sustainable Energy Reviews,* vol. 75, pp. 1022-1034, 2017.

[53] A. Alam, I. Malik, A. B. Abdullah, A. Hassan and U. Awan, "Does financial development contribute to SAARC'S energy demand? From energy crisis to energy reforms," *Renewable and Sustainable Energy Reviews,* vol. 41, pp. 818-829, 2015.

[54] D.-W. Kima, J.-S. Yub and K. Hassanc, "Financial inclusion and economic growth in OIC countries," *Research in International Business and Finance,* vol. 43, pp. 1-14, 2018.

[55] R. Sahay, M. Cihak and P. N'Diaye, "Rethinking Financial Deepening: Stability and Growth in Emerging Markets," *Revista de Economia Institucional,* vol. 17, no. 33, pp. 73-107, 2015.

[56] B. Chimbo, "Information and Communication Technology and Electricity Consumption in Transitional Economies," *International Journal of Energy Economics and Policy,* vol. 10, no. 3, pp. 296-302, 2020.

[57] G. Kudamaa, D. Mabiratu, H. Wana and B. Tadese, "Will digital solution transform Sub-Sahara African agriculture?," *Artificial Intelligence in Agriculture,* vol. 5, pp. 292-300, 2021.

[58] P. Mulder, H. De Groot and B. Pfeiffer, "Dynamics and determinants of energy intensity in the service sector: A cross-country analysis, 1980–2005," *Ecological Economics,* vol. 100, pp. 1-15, 2014.

[59] P. Schulte, S. Rexhäuser and . H. Welsch, "ICT and the Demand for Energy: Evidence from OECD Countries," *Environmental and Resource Economics,* vol. 63, pp. 119-146, 2014.

[60] A. Szklo and R. Schaeffer, "Fuel specification, energy consumption and CO2 emission in oil refineries," *Energy,* vol. 32, no. 7, pp. 1075-1092, 2007.

[61] N. Odhiambo, "Energy consumption, prices and economic growth in three SSA countries: A comparative study," *Energy Policy,* vol. 38, no. 5, pp. 2463-2469, 2010.

[62] M. Appiah, F. Li and B. Korankye , "Modeling the linkages among CO2 emission, energy consumption, and industrialization in sub-Saharan African (SSA) countries," *Environmental Science and Pollution Research,* vol. 28, p. 38506–38521, 2021.

[63] Z. Asghar, "Energy-GDP Relationship: A Causal Analysis for the Five Countries of South Asia," *Applied Econometrics and International Development,* vol. 8, no. 1, pp. 168-180, 2008.

[64] K. Ahmed, M. Ur Rehman and I. Ozturk, "What drives carbon dioxide emissions in the long-run? Evidence from selected South Asian Countries," *Renewable and Sustainable Energy Reviews,* vol. 70, pp. 1142-1153, 2017.

[65] D. Vedia-Jerez and C. Chasco, "Long-Run Determinants of Economic Growth in South America," *Journal of Applied Economics,* vol. 19, no. 1, pp. 169-192, 2016.

[66] G. Reyes and A. Useche, "Competitiveness, economic growth and human development in Latin American and Caribbean countries 2006-2015: a performance and correlation analysis," *Competitiveness Review: An International Business Journal,* vol. 29, no. 2, pp. 139-159, 2019.

[67] A. Acheampong, "Economic growth, CO2 emissions and energy consumption: What causes what and where?," *Energy Economics,* vol. 74, pp. 677-692, 2018.

[68] M. d. P. Pablo-Romero and J. De Jesús, "Economic growth and energy consumption: The Energy-Environmental Kuznets Curve for Latin America and the Caribbean," *Renewable and Sustainable Energy Reviews,* vol. 60, pp. 1343-1350, 2016.

[69] I. Ackah and R. Kizys, "Green growth in oil producing African countries: A panel data analysis of renewable energy demand," *Renewable and Sustainable Energy Reviews,* vol. 50, pp. 1157-1166, 2015.

[70] W. M. Ssali, J. Du, D. O. Hongo and I. A. Mensah, "Impact of Economic Growth, Energy Use and Population Growth on Carbon Emissions in Sub-Sahara Africa," *Journal of Environmental Science and Engineering,* pp. 178-192, 2018.

[71] A. R. Office of the Chief Economist, "Africa's Pulse," World Bank Group, Washington, 2015.

[72] S. Chakravarty and R. Pal, "Financial inclusion in India: An axiomatic approach," *Journal of Policy Modeling,* vol. 35, no. 5, pp. 813-837, 2013.